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Interactive Multimedia Design Features
Their Derivation, Application and Assessment in Electronic Shopping

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Abstract

The aim of this thesis is to investigate interactive multimedia design: from the analysis of problems with multimedia systems to the subsequent derivation of design features and their assessment. It concentrates on the application of interactive multimedia from a user-centred perspective to rational, choice-based decision making in electronic-shopping, and specifically as a solution to the difficulty consumers have in judging product quality.

The popularity and widespread use of interactive technologies, especially the Internet, the complexities of multimedia design, and the importance of electronic-shopping make the need for this investigation timely.

The research approach consisted of the following: the derivation of design features through analysis of designs, interviews with designers and review of relevant literature; application of design features through an understanding of problems with electronic-shopping and development of a prototype shopping environment; and assessment of the features through empirical work.

The thesis produces three key findings. First, a set of six design features to support multimedia design: naturalness/realness, media allocation and combination, redundancy, significant contribution of the media, exploration, and quality of information representation. Second, a better understanding of multimedia design decision-making. And third, the application of interactive multimedia product experience to improve online consumer behaviour.

The research makes contributions to the areas of Human-Computer Interaction and Electronic Commerce, and offers practical recommendations to designers of interactive multimedia, especially when part of their design problem involves support for users' interactions with representations of choice alternatives.

Chapter 1 Introduction

"Science is a series of successive approximations. Not all things can be done at once, and even if one aspires to go far, he must start somewhere."

Allen Newell and Herbert A. Simon, Human Problem Solving (1972)

Over fifteen years ago, the use of the Internet by the general public, i.e. not only experts in computer systems, became a reality. As more and more people engaged in the Internet revolution, electronic shopping (e-shopping) through the World Wide Web (WWW) became one of the main attractions of the technology, allowing consumers to buy a wide variety of products from books to holidays, from toothbrushes to cars without leaving their homes or workplaces. Among the benefits of e-shopping for consumers can be cited: convenience - less travelling, shop any time of day, on any day - and more product choices; for books alone, online bookstores can stock more than 5 million titles whilst conventional big bookshops typically house less than 200 thousand titles. However, despite the fact that e-shopping has become one of the success stories enabled by the increase in connectivity to the Internet, it is far from being a mature technology. Surveys have revealed that for many consumers who have tried it, the Internet is not a viable way for shopping due to its shortcomings in the description of products. They prefer to feel, see, touch and sample the product before buying it and many consumers who do shop online think the products' descriptions could be much improved so as to enable better choices. The fact is that the rapidly expanding electronic shopping marketplace has opened the doors for new research in Human-Computer Interaction (HCI). The question most commonly asked is how to design e-shopping websites taking into account both user experience and utility.

Even before the Internet became widespread, another piece of technology, multimedia, was already popular with the advent of the so called multimedia computers. For this thesis, a broad definition of multimedia is adopted as being multisensory user experiences that enable us to communicate with computers with all our senses[1]. Being heralded by many as the cure to all our interactivity problems, multimedia was used (and abused) by many designers who had little knowledge of HCI research. In many cases, the use of multimedia with no set criteria made interaction even worse, with sounds, images and videos appearing, just because multimedia was supposedly the way forward. On the other hand, even researchers who were desperately trying to make sense of this new technology did not agree on certain issues, such as how to combine media successfully (Rowe and Jain 2005). Nowadays the problem of multimedia design has increased its importance with the emergence of amateur photography and videography and the availability of an enormous amount of digital pictures, online video sharing, and social networks (Li, Chang et al. 2007). This means that it is increasingly important to adequately support human activities that need access to this data (Jaimes, Sebe et al. 2006), including the advantages of multimedia without its disadvantages.

This thesis studies the HCI of multimedia and its application in electronic shopping. It concentrates on the application of interactive multimedia from a user-centred perspective to rational, choice-based decision making in electronic-shopping, and specifically as a solution to the difficulty consumers have in judging product quality.

There are many reasons to pursue such endeavour. Currently, approximately two billion people (or 30% of the world's population) use the Internet. Since multimedia technology is available, there are many opportunities to use it. Without a good understanding of when to use and how to design it, it could be overused in certain situations and underused in others, affecting many of its users

[1] Different definitions of multimedia will be examined in Chapter 2.

negatively. Specifically in e-shopping alone, £58.8 billion was spent on purchases by consumers in the UK in 2010[2] (a growth of 18% from 2009); in the US, the amount was £170 billion[3]. Even a small improvement in consumer-computer interaction could have a widespread positive impact on society. The magnitude of the problems consumers face can be appreciated with some data gathered by market research companies:

- 42% of 1,179 online consumers surveyed have left a site without buying a number of products because they could not find answers about one of the products in their shopping basket; 41% decided not to make a planned purchase because they couldn't readily find a piece of information about the product or service (Evans 2007)
- 76% of online shoppers surveyed report that content is insufficient to complete research or purchase online "always, most often or some of the time." (eTailingGroup 2007)
- incomplete content is also a factor as 79% “rarely or never” purchase a product without complete product information (eTailingGroup 2007)
- online businesses lose as many as 67% of consumers due to a lack of online product information (Allurent 2008)

As can be seen, many of the problems are related to product information. The provision of adequate product information following a user-centred design perspective would not only better support current e-consumers, but also make e-shopping a more attractive alternative to sceptic shoppers.

The ultimate goal of this thesis is to improve the design of interactive multimedia systems to support rational decision making. Considering, for instance, multimedia used in electronic-shopping, who will benefit from the research outcomes of this thesis? To answer this question, the origins of and reasons for the problems consumers face while interacting with e-shops will need to be identified. This is not a simple task, but by analysing systems it can be seen whether either the designer has failed to apply HCI principles and guidelines, or research has failed to find these. If the principles and guidelines are there and designers fail to apply them, it follows that the HCI community has a problem communicating or educating its public. On the other hand, if there is no guidance to designers, then researchers are failing to address this problem. In this thesis, these questions are asked: do we have and, if not, do we need multimedia design principles and features? If it can be shown that the issue of interaction with media is not entirely understood by researchers, then there is a case for the development of a more comprehensive understanding of this. In this respect, the main beneficiaries of such knowledge are not only researchers, but also designers.

Having set context and motivation, the remainder of this introductory chapter will:

- provide a high level background to the area
- examine the problem statement
- introduce goals
- introduce contributions of the thesis
- present an overview of the remainder of the thesis

1.1 Background

In order to deal with the complexities of the issues involved in the use of multimedia in general and in e-shopping in particular, the problem is divided into two parts, namely multimedia systems and

[2] Source: Interactive Media in Retail Group (http://www.imrg.org)

[3] Source: http://www.fortune3.com/blog/2011/01/ecommerce-sales-2011/

e-shopping. By working on them separately, a good understanding can be achieved of how to apply multimedia to e-shopping systems.

Research on multimedia has been historically intertwined with the work on hypertext and hypermedia (Cunliffe and Tudhope 2010). In fact, they are frequently treated as synonyms. In this respect, the origins of research on multimedia can be traced back to the works of Bush (1945) who developed the concept of the first hypertext/hypermedia system, Engelbart (1968) who built one of the first hypertext systems, and Nelson (1994) who coined the terms hypertext and hypermedia. Heralded by some as the next evolution in interface design at the beginning of the nineties (Preece and Shneiderman 1995), multimedia technology was marketed as the solution for all interaction problems (Hughes 1999). Several studies have been performed testing the effects of multimedia, but these studies achieved conflicting results in terms of positive and negative effects (Faraday 2000), making it difficult for researchers to understand the variables involved in the design of effective multimedia.

In terms of HCI and multimedia, there are two ways to see their relation. Firstly, how multimedia technology can be used to improve the experience of user interaction and secondly, how research on HCI can improve multimedia itself, i.e., how to improve the usability of multimedia. These are two sides of the same coin: on one side, its utility and on the other its usability, respectively.

Research on electronic shopping, as known today, started with the advent of the World Wide Web and the graphical browser (circa 1994). However, precursors to the Internet, like the European teletext (videotext), also provided ways to browse for products and buy electronically from home. Videotext uses television signals to broadcast data for the provision of information (e.g., television schedules, news, weather forecasts, financial information, etc). Its roots lie in the 1970s, when the BBC started the first services in Britain and the system is still being improved, nowadays with digital television. In the 80s, teletext was also used for shopping, although it never actually achieved popularity for several reasons. For instance, apart from the fact that the speed of the communication channel was very slow, the lack of decent graphical capabilities was a difficult obstacle to overcome – this problem and its consequences will be described in Chapter 5.

Many of the problems with teletext related to transmission speeds and quality of graphics were solved by a new technology, the World Wide Web. As soon as graphical browsers became popular, the first e-shopping websites started to appear (August 1994 is considered the birth of e-shopping on the Internet[4]). For many, the first retail shop to take full advantage of the web was Amazon.com, when it started selling books in 1995. The main problem with e-shopping at that time was security: consumers were concerned about sending their credit card numbers via the Internet (Bhatnagar, Misra et al. 2000). Today, after huge investments in secure protocols, consumers are more comfortable than ever with shopping online[5]. Whilst security is still something that research and industry regard as crucial for consumers, the focus has shifted to issues surrounding interactivity, which is where multimedia comes in.

The use of multimedia technology for e-shopping has been investigated by two different communities: HCI researchers and consumer behaviour researchers. The HCI community has concentrated research into agents and virtual shop assistants, trust, social aspects, loyalty, 3D presentations of products and personalisation. The main problem is that HCI researchers lack specific knowledge about consumer behaviour and the way consumers make purchasing decisions. The consumer behaviour community, on the other hand, has approached the field with a more

[4] Arguably the first transaction took place on 11 August 1994, when the company NetMarket sold a copy of Sting's CD "Ten Summoner's Tales" for $12.48.

[5] In Chapter 5, a survey will be presented that ranks the main problems people have with e-shopping.

marketing oriented perspective, researching the use of multimedia to see if it can persuade consumers to spend more money and, consequently, increase sales and profit.

1.2 Problem Statement, Goals and Methods

The main characteristic of e-shopping is that the physical product is not present, which means that the online consumer can only passively receive product information. This means that there is no touching, sampling, or feeling of products being sold online, before the purchase decision. Consequently it becomes difficult to judge the quality of some products in order to make a rational product choice. For this reason, several researchers have still questioned the effectiveness of online shopping (Bhatnagar, Misra et al. 2000; Lowengart and Tractinsky 2001). However, there are possible ways to improve this situation: one of them is using multimedia technology.

Given this context, this thesis addresses the following research questions:

- What are the main characteristics of interactive multimedia systems that enable users to gain an appreciation of the things they represent?
- What design features are required to guide interactive multimedia design?
- How can interactive multimedia design features be applied to rational decision making in e-shopping?
- Does it generate a user-experience improvement?

In order to examine these questions, this thesis has the following research goals, presented with corresponding research methods:

Goal	Method
1. to identify design features of multimedia systems	theoretical and analytical investigation of multimedia systems
2. to understand the criteria designers use when making design decisions related to multimedia	interviews with designers and subsequent thematic analysis
3. to identify the main problem consumers face when shopping electronically	survey and investigation, based on consumer behaviour theories and models
4. to understand consumer behaviour models and their relationship to e-shopping	analysis of findings from the consumer behaviour literature, and its application to e-shopping
5. to identify gaps in the research that has been done to benefit consumers	analysis of current studies in the area
6. to design and develop a realistic electronic store prototype using multimedia technology to make product inspections, applying the multimedia design features	reuse of existing realistic material that satisfies the criteria of product inspections
7. to assess the use of multimedia technology as a way to solve the main problem consumers have with e-shopping	design and execution of a controlled experiment with a prototype online store
8. to recommend to designers when to use multimedia technology for e-shopping	derivation of implications for design from the analysis of the literature, from the design of a prototype e-shopping website, and from the results of the empirical work
9. to advise HCI researchers on how to improve research in e-shopping	derivation of implications for research from the results of the experiment contrasted with findings

published in the literature.

1.2.1 Relationship between research questions and goals

The mapping of research questions into research goals is shown in Table 1. It is important to note that some of the goals cover more than one research question.

Table 1 Mapping research questions into goals

Research question	Goals
What are the main characteristics of interactive multimedia systems that enable users to gain an appreciation of the things they represent?	1, 3
What design features are required to guide interactive multimedia design?	1, 5
How can interactive multimedia design features be applied to rational decision making in e-shopping?	2, 4, 7, 8, 9
Does it generate a user-experience improvement?	6, 7

1.3 Results and Contributions

By achieving these goals the HCI community can be provided with an overview of interactive multimedia technology and a deeper understanding of the nature of electronic shopping, and the application of the latter to the former. Therefore it is the goal of this thesis to make a contribution both from research and design perspectives.

In terms of research, the thesis organises the multimedia field in an original way, creating several new opportunities for investigatory questions. It also develops a strong argument that explains an important problem with electronic commerce. It provides novel empirical evidence about the way multimedia technology can make a positive contribution to electronic shopping. In terms of design, the thesis contributes with a set of design features that can support designers when making media choices. It also contributes to the understanding of multimedia design rational decision-making. Additionally, it makes a case for the use of multimedia in electronic shopping environments with interactive multimedia product presentation. It aims to inform designers when and how to use the technology to improve interaction.

Most of the work researching consumer behaviour in e-shopping is done by researchers in marketing, consumer behaviour and advertising. These disciplines view the whole shopping process in terms of marketers, whose main goal is to sell more, to persuade, and ultimately increase profits. Previous research has wanted to find out what makes a consumer decide whether or not he/she will buy a product; and this is an appropriate dependent variable for research directed towards companies (Bazerman 2001). However it does not address issues related to helping individuals make wiser purchasing decisions. Ultimately, the ideal is to maximise the consumer's expected welfare, by giving him enough information to make a decision that is best for him.

This thesis takes a different perspective in the sense that it advances knowledge aimed at helping the consumer to benefit from better designs, which will support improved rational decision making.

The interest is in decision behaviour when a person is faced with a purchasing problem of some novelty and complexity[6], a problem that is worthy of in-depth study as it affects many consumers.

1.4 Overview of the Thesis

The remainder of this thesis is structured as follows:

Chapter 2 sets the background around multimedia technology: definitions, benefits, and, through analysis, some of the main problems.

Chapter 3 shows the relevance of the problem from the point of view of designers. Through a qualitative study with interaction designers, we understand what sort of criteria they employ when using interactive multimedia in real-world designs.

Chapter 4 derives interactive multimedia design features. This is one side of the problem that this researcher is trying to contribute for – design of multimedia systems – arriving at design features with the goal of improving design. Whilst it is possible to have multimedia it is not at all obviously known how to design high-quality multimedia systems that are fully usable to the degree that should be expected. Several researchers have manifested the need for establishing design criteria and principles for multimedia, the "need to move away from intuitive beliefs and trial and error experiences of designers" (Weiss, Knowlton et al. 2002, p. 466). This would enable designers to build interactive multimedia systems that provide a better user experience, moving from a craft style design approach to a more systematic principle-based approach.

Chapter 5 describes the other side - electronic shopping - finding the problems with it, and concluding with this researcher's proposal for how to improve it by using multimedia technology. This chapter makes a case for the use of multimedia in product inspections, as in e-shopping it is not possible to experience the products directly. The fundamental problem consumers have while making decisions using the WWW is perceived performance risk that happens when a consumer is uncertain if the product will perform as expected. The argument is based on the decision-making process model, and the attributes of the products involved. It is then argued how the use of multimedia product experience can reduce the risk perceived by consumers. A case is also made for tools that enable comparisons between products, which are also related to the way people shop for them.

Chapter 6 generates hypotheses derived from the application of the multimedia design features in an electronic shopping environment. Each hypothesis is expressed in relation to interactive multimedia and comparison tools.

Chapter 7 describes the prototype electronic shop developed with the application of the multimedia design features. It is also used to test the hypotheses. Based on real information, the shop is populated with existing products appearing to be a real shop. Four different versions of the shop were produced for empirical evaluation.

Chapter 8 reports on a laboratory experiment with four different designs for an online shop that sells digital cameras. Subjects were observed performing five shopping tasks. Products were presented in different levels of multimedia; comparisons for products attributes were also manipulated. Both objective and subjective measures are used to derive some conclusions about the effects on user experience. The experimental design and procedures are presented followed by the results.

[6] In this context, complexity refers to the number of different attributes of a product. Novelty involves unexpected or unfamiliar aspects of a product.

Chapter 9 presents a discussion of the results. They are presented to show the effects of multimedia and comparison tools on consumer behaviour. The chapter concludes with implications of the results in terms of design and research.

At the end of this thesis, in C**hapter 10**, the main findings and contributions of the presented work are summarised and the conclusions presented. Some goals for future work are suggested.

The **Appendices** contain the experimental materials used: questionnaires, tasks and learning test.

Chapter 2 The Problem with Multimedia Systems[7]

"…it is necessary, while formulating the problems of which in our advance we are to find solutions, to call into council the views of those of our predecessors who have declared an opinion on the subject, in order that we may profit by whatever is sound in their suggestions and avoid their errors"

Aristotle, De Anima

2.1 Introduction

The main goal of this chapter is to consider the problems designers face when using multimedia technology, and to show the need for multimedia design features. After contextualising research on HCI aspects of multimedia, it will first of all be necessary to define multimedia. The problems facing multimedia design will then be considered, before introducing the design features.

Multimedia technology can considerably increase the options open to the user interface designer (Johnson and Nemetz 1998; Alty 2004). However, the lack of detailed design knowledge and widely available design experience mean that the design and evaluation of multimedia user interfaces are unprincipled activities (Sutcliffe 2003). Although multimedia user interfaces offer many interesting possibilities for design, they not only increase the complexity of design, but also increase the potential for bad design. Sutcliffe (2003) stressed that "poorly designed multimedia can, at best, fail to satisfy the user's requirements, and at worst may be annoying, unpleasant, and unusable" (p. 3). One reason for the production of poor interfaces is the high number of options and combinations that multimedia interface design offers (Alty 1993).

Using the most advanced technology does not necessarily guarantee an improvement on the user experience of current systems. And merely relying upon naive assumptions, beliefs and intuitions of the designer is not enough to bring about a large-scale improvement in the quality of interactive multimedia systems (Nemetz and Johnson 1998b).

The lack of guidelines and principles forces designers to rely on their intuition, especially as they constantly have to face new and unfamiliar design problems. The problem is that the intuition of the human mind is an unreliable basis for the designing process (Landauer 1995). Providing clear guidelines and principles is vital in aiding multimedia designers to improve the quality of their work (Alty 2004)[8].

The main theories used in Human-Computer Interaction (HCI) have been shared by, or borrowed from, cognitive psychology and cognitive science (Sutcliffe 2000). These theories have proven effective in modelling the human cognitive processes of multimedia that occur in the natural communications between people that simultaneously employ spoken language, body language, gesture, and touch (Arens, Hovy et al. 1993; Alty 2004). However for technology-driven media this is not always the case (Bunt 1998). Given all the complexities inherent in multimedia and the shortcomings of HCI theories, there are difficulties in applying such technology in a predictable way that can guarantee usable interactions.

What does research say about multimedia and its interactive technologies? A solid body of research has now been accumulated over the years, which has advanced the field. For instance, one of the

[7] Some parts of this chapter are based on Johnson and Nemetz (1998) and Nemetz and Johnson (1998a).

[8] The problems designers face when making decisions related to multimedia design will be presented in Chapter 3.

domains where multimedia has been most studied is education. Several experiments were undertaken to test and understand the effects that multimedia has on learning. However, the findings have been inconsistent and inconclusive (Bhowmick, Khasawneh et al. 2007). Burton, Moore and colleagues (1995) stated that researchers in the educational field commonly have difficulties in determining the reasons why multimedia is more (or less) effective than conventional instruction. Does this mean multimedia has no use in education? Absolutely not. On closer examination of 46 studies analysed by Liao (1999), it would appear that many multimedia applications have poorly designed interactions, and hence ineffective for learning. Thus, the problem is not to be found in multimedia itself, but in its interaction design (Rogers and Scaife 1998). Najjar (1996a) analysed several studies that did not support the positive effects of multimedia on learning, and showed that in these studies multimedia discouraged the learner to elaboratively process the information[9]. There appears to be some support for this elaboration hypothesis. However, an HCI view of multimedia should go beyond the investigation of issues that only involve learning tasks.

Unfortunately, despite the fact that multimedia has received a great deal of attention by researchers, developers and standard bodies (e.g., ISO 14915), designers still lack a theoretical basis from which to enquire about the utility of multimedia and its effects on usability. Many of the current guidelines for the development of multimedia applications can be traced back to assumptions, intuitions, and (apparently) basic common sense (Burton, Moore et al. 1995). For example, one guideline for animation in the literature states that "… animation should be used sparingly to avoid distraction!" (Dix, Finlay et al. 2004, p. 752). It is well known that distraction can be caused by the excessive or irrelevant use of dynamic media such as animations (Johnson and Nemetz 1998); however the above guideline is given without any consideration of the nature of the task, the characteristics of the user, and the characterisation of the context. It is the same as stating in a book about architecture, that the size of the windows should be kept to a minimum to avoid too much sunshine. In another example - "Video and audio are more powerful when combined rather than isolated" (Jain 2003) - there is no explanation of what exactly is meant by "powerful", nor is there any mention of situations or contexts to which this statement may apply. In fact, choice and combination of media is a complex design decision, which is dependent on the type of information being conveyed.

The principles for HCI design, such as consistency, user control, feedback, are, of course, essential in multimedia design. However, as noted by Bearne, Jones et al. (1994), the problem with multimedia design is that *traditional approaches for usability, undertaken in the HCI discipline, have not yet dealt directly with the unique characteristics of multimedia systems:*

> *"while general usability criteria such as learnability, flexibility and robustness apply equally to single media and multimedia systems, they have little to say regarding the specific benefits and drawbacks of concurrent media input and output" (p. 105).*

Design approaches to the use of multimedia have advanced considerably since Bearne and colleagues wrote that, but there is still a lot of research to be done so that designers can benefit from it.

Sutcliffe (2003) argued that the specific requirements of multimedia should mainly focus on the presentation of information, because most applications are information intensive. He was of the opinion that the interactive aspect of multimedia "can be treated as an extension of standard GUI interaction" (p. 108), i.e. only the presentation element has changed. However, this researcher disagrees with this argument, as interaction in multimedia systems can be mediated in different ways, e.g., speech, natural language, touch and gesture, which refutes Sutcliffe's argument.

[9] It is important to note that the majority of these studies have not provided enough details of the designs, making it even more difficult to produce a detailed analysis.

Another interesting recurrent discussion is the fact that many researchers have considered multimedia to be pure art (Arens, Hovy et al. 1993), whilst others have viewed it as a purely engineering discipline (Isakowitz, Stohr et al. 1995). Actually, "multimedia lies on an interesting cultural boundary between the creative artistic community and science-based engineering" (Sutcliffe 2007, p. 394). Possibly because diverse traditions are responsible for its distinctive roots, the development of multimedia systems has been characterised by a lack of consensus (Lang 2002). One of the challenges designers face is having to interact with people from a variety of backgrounds, who often have different vocabularies and little in common. Although not unique to multimedia development, this situation is exacerbated by the complexities in dealing with the production and integration of different media in a computational environment. Recognising its multidisciplinary nature, several institutions have offered undergraduate courses in multimedia, hosted by faculties of arts and information technology or science (Gonzalez 2000). Nevertheless, it will be a long time before multimedia professionals who are fluent in two or three knowledge domains will be seen. Even then their skills will not necessarily cover the full range of backgrounds, from art to information science, from interaction to media production, that need to be considered in a multimedia development project.

For Arens, Hovy et al. (1993), despite the fact that "this area remains an art, people do follow rules when they use several media to construct communications" (p. 281). The question is: what are these rules and where do they come from?

Given these issues, how can HCI help multimedia? HCI can move it from a technology-centred design (linking different types of media and seeing what the user is able to accomplish with them) to a user-centred design (asking what the user wants to do with this new technology) (Alty 1991). Moreover, what can multimedia do for HCI? Multimedia technology has the potential to improve human-computer interactions in two ways (Maybury 1993): (i) it can increase the bandwidth of information flow between humans and machines, and (ii) it can make more of the information communicated useful.

Multimedia systems promise a greatly increased intuitiveness into the interaction between users and computing systems (Bernsen 1997). These potential benefits, however, do not come naturally with the technology; they still have to be designed. The remainder of this chapter identifies a number of issues that need to be taken into account in the design of multimedia systems, from the perspective of human-computer interaction. These issues are grouped around six design features: Naturalness and Realness, Media Allocation and Combination, Redundancy, Significant Contribution of the Media, Exploration, and Quality of Information Representation. But first a definition of multimedia is required.

2.2 Definition of Multimedia

Owing to the diverse nature of multimedia, a definition is problematic causing many multimedia experts to feel they need to give their own definition. If six different multimedia experts were asked for a definition, it is likely that six different definitions would be the result (Reisman 1998). Despite this, however, multimedia has become one of the most important areas of research in the past 20 years.

Historically, multimedia has been defined in several ways, depending on the discipline (e.g., communications, educational software, computer graphics) and focus (e.g., technological, biological, physical) (Hess-Luttich 1994). This polysemous term makes it difficult to achieve consensus, even if only the broader field of HCI is being considered. For instance, the following are definitions from some of the widely used HCI textbooks. Whilst Dix, Finlay et al. (2004) characterised multimedia systems as systems that "use a number of different media to communicate supplementary, additional or redundant information" (p. 556), for Preece, Sharp et al. (1994), a multimedia application is "any computer application that employs a video disk, images from a CD-ROM, uses high quality sound, or uses high quality video images on screen" (p. 255)[10]. The first definition concentrates on different ways to put information together, whereas the second is entirely based on technology, prescribing specific storage devices (video disk and CD-ROM) and also establishing that a computer application simply playing a piece of music is considered a multimedia application[11] (Purchase 1998) as long as it has high quality sound. In contrast to definitions based on technology, Marmolin (1991) offered a useful alternative perspective:

> *"From the user's point of view, the multimedia technology is not as important as the possibilities offered by the technology*."

Emphasising the potential benefits multimedia can offer to the user, rather than what it technically comprises, Marmolin advanced a user-centred perspective to the discussion:

> *"A user centred definition would characterise multimedia systems as systems enabling the usage of multiple sensory modalities and multiple channels of the same or different modality (for example both ears, both hands etc.), and as systems enabling one user to perform several tasks at the same time. That is, multimedia is viewed as a multisensory, multichannel, multitasking and multi-user approach to system design. In addition multimedia systems put the user in control, i.e. could be described as a user centred approach" (Marmolin 1991).*

Baecker, Grudin et al. (1995) defined a multimedia computer system as "one that transacts or interacts in more than one medium, i.e., carriers of information such as text, audio, still graphics, animation, and video" (p. 837). With this definition, the start of an attempt to characterise and exemplify media can be seen. Roth and Hefley (1993) also defined media as carriers of information, but on a different level of abstraction, giving as examples: natural language text, information graphics, maps, realistic graphical depictions, photographs and music. Complicating this, Arens, Hovy et al. (1993) made a distinction between medium (a single mechanism by which to express information, e.g. spoken and written natural language, diagrams, sketches, graphs, tables, pictures) and information carrier (part of the message that communicates the principal piece of information requested or relevant, e.g., a marker on a map). Heller, Martin et al. (2001) differentiated between multimedia and multiple media: "multimedia is defined as the seamless integration of two or more media" (p. 1). If two or more media are attached to each other, but not seamlessly, they referred to them as multiple media. On the other hand, Maybury (1993) defined multimedia interfaces as "computer interfaces that communicate with the users using multiple media (e.g., language, graphics, animations, video, non-speech audio)". It would appear that each definition explores one or more facets of multimedia. Hess-Luttich (1994), for instance, used the term medium to refer both to the material object (e.g., paper, video) as well as the means by which information is conveyed (e.g., a sheet of paper with text on it, speech, graphics, video).

Illustrating the polysemous nature of multimedia, Hess-Luttich (1994) presented several notions of media according to their usage in everyday life, among them:

- **biological**: refers to the sense modalities (e.g. visual, auditory or tactile media);
- **physical**: refers to the physical contact matter of communication (e.g. optic, acoustic or haptic media);

[10] The same authors (different, but more up-to-date book) (Rogers, Sharp and Preece (2011) make the definition a bit better: (multimedia) "combines different media within a single interface, namely, graphics, text, video, sound, and animations, and links them with various forms of interactivity." (p. 173).

[11] By the same definition, it could be argued that if the quality of the sound is low, it could not be considered multimedia.

- **technological**: refers to the technical equipment of communication and its products (e.g. printing media (e.g. newspapers) or screen media (e.g. television);
- **sociological**: refers to the institutions for the organisation of communication processes (e.g. news agencies, television companies, cultural enterprises and their management).

It is interesting to see that Hess-Luttich's biological notion of media treats sense modalities and media indistinctly. Alty (1997) stated that in HCI output media are employed to communicate with users, whereas input media are used to interpret what the users are communicating to the computer system. Other authors, though, have distinguished between (output) media and modalities. For instance, for Sutcliffe (2003) sense modalities refer to the senses (vision, hearing, touch, and less commonly, smell and taste) by which a message is perceived by a person; hence, "a message is conveyed by a medium and received through a modality" (p. 14) [12]. Roth and Hefley (1993) offered a different view, claiming that a multimodal interface is the same as a multimedia interface, only that the former is seen from the perspective of a user, and the latter, from the perspective of a system.

Furthermore, in contrast to Hess-Luttich's physical notion of media, Sutcliffe (2003) defined physical media as the technology for storing or delivering the message (ex., DVD, CD-ROM, hard-disk). He defined perceived (or perceptual) media as the way the message is presented and perceived (e.g., image, speech, sound) rather than the technology for storing or delivering a message.

Bernsen (1996) defined a multimedia system as "one which outputs information in several media, either simultaneously or sequentially" (p. 2)[13]. Besides Bernsen, many authors (Marmolin 1991; Laurel 1993; Nielsen 1995; Najjar 1996b; Najjar 2001; Chapman and Chapman 2009) have restricted multimedia to the output of information. For example, for Najjar (2001) "multimedia user interfaces combine different media such as text, graphics, sound, and video to *present* information", and for Laurel (1993), "Multimedia refers to systems that *deliver* more than text and graphics in their visual displays (typically, photographic images, audio, or video)" (p. 178). However, the delivery of media, as in multimedia presentations (Alty 1991), is only half of the story. As mentioned by Morris and Maes (2000), multimedia should include all systems that integrate diverse media, either for presentation (multimedia delivery systems) or communication, which implies a two-way interaction. Communication was also emphasised by Sutcliffe (2003), who considered multimedia as being "multisensory user interfaces, that is, advanced user interfaces that enable us to communicate with computers with all our senses" (p. 1). As pointed out by Alty (1991),

> *"Multimedia interfaces are not just about extending the choice of media available, more importantly they are about improving interfaces to computers by improving the communication bandwidth in such a manner that human beings will find themselves in a more advantageous position" (p. 41).*

In summary, the problem with the definitions of multimedia is that they are either based purely on the technology involved, or on a particular notion of media. Moreover, a definition can also focus only on the delivery (output) of information with the exclusion of any form of interaction. Whilst a precise definition is difficult to achieve, in this work a wider definition will be adopted, encompassing both input and output media (following the example of Alty (1997)), and focusing

[12] Human beings have not yet developed a language based on smell and taste; smell and taste in human beings are often used for detection rather than for communication (Tufte 1983, p. 37) (Rowe and Jain, 2005)

[13] Bernsen emphasised graphics, acoustics and haptics as the "media of today", and that will be prevalent in multimedia systems for the foreseeable future.

on human-computer interaction rather than on the technological aspects. The concept of media used here is in line with Sutcliffe's notion of perceptual media and Bersen's taxonomy of media (graphics, acoustics, and haptics). In this way, interactions with animations, gesture recognition, simulations, speech input, speech synthesis, haptic input and output, and virtual reality are considered as examples and/or special cases of multimedia. These technologies can potentially enhance sensory experience, so broadening the experience of reality. Some researchers have chosen to give these technologies a different name, such as multisensory user interfaces (Sutcliffe 2003), however they will be referred to here simply as multimedia interfaces, as multimedia is an established concept, although as has been seen, a very diverse one.

2.3 Interactive multimedia from a user-centred perspective

With so many claims that technology is there to simplify our lives ("a picture is worth a thousand words") (Blackwell 1998), the introduction of multimedia is no exception. When multimedia is well exploited by designers, it has the potential of making interfaces more exciting, more natural, and more enjoyable and pleasant to use than traditional mainly text-based interfaces (Petersen 1998). The use of multimedia provides us with richer forms of representing information in human-computer interactions. Furthermore, Marmolin (1991) stated that multimedia interaction can augment human abilities, and is more engaging than the use of one medium alone, as it encourages active exploration of information, and provides a rich source of material for the mind which is normally drawn to dynamic rather than static stimuli. Another claim is that multimedia interaction increases the information bandwidth and improves the mind's attention span and this increases user comprehension, because users are able to perceive and interpret more information.

However, it does not necessarily follow that by merely increasing the richness of the media the utility and usability of information and computer systems will also be increased. While in some cases the addition of more media might allow us to express concepts and information more fully, and with greater clarity, and accuracy than before, in other cases it can introduce ambiguity, confusion and contradiction. Because the costs of building multimedia systems are usually high (Barry and Lang 2001), it is essential that designers take these aspects into account and work to minimise usability problems.

Some of these problems are related to the widespread use of multimedia technologies and misconceptions of what multimedia itself is. For instance, Hughes (1999) complained about the problems created by the definition: "Insofar as multimedia had a definition, it was that it allowed you to integrate text, graphics, and sound within a computer application. This had the unfortunate effect of implying that all you had to do, to create successful multimedia, was to integrate lots of those things."

It may be argued that principles and guidelines are needed to support the design of multimedia systems, but if designers are successfully fulfilling their roles without abiding by such principles then there is no need to be overly concerned. In order to assess whether this is the case, an analysis of several classes of multimedia systems was carried out by this researcher (Johnson and Nemetz 1998) and from this the conclusion was arrived at that there is, indeed, a problem with multimedia design. Although the classes of multimedia systems that have been considered are not exhaustive, they do represent different system types. Applications on the World Wide Web that provide information on and guidance to a particular domain have been covered. Examples of these are tourist guides or conference websites. This class of information is designed to let the user find particular information and to "browse" through the information that is there. One example of a comparatively well designed web-based tourist guide that this researcher came across is the Scotourist guide, which is considered below[14].

This guide is a realistic and highly engaging public information system that is widely used. It is by no means an example of a poor information system or one that has made outrageous use of multimedia. However, when looking closely at the design, it is quickly discovered there are features that exemplify the lack of design principles that appears to be associated with the use of multimedia. The system in question makes use of: text, diagrams, maps, photographs, animation and hypermedia. Figure 1, Figure 2, Figure 3 and Figure 4 present four examples taken from this system. These examples have been chosen in an attempt to reflect the system as a whole, as the problems illustrated here and discussed below are to be found throughout the design.

Figure 1 shows part of the contents page of the guide. The page has an attractive layout out and is well designed in terms of the readability of the text and the structuring of information. However, there are problems with the animations found on this page. First, the compass in the top-left hand corner has a lid on it that opens and closes independently of the user's activity. Second, the star-like compass points alongside the text rotate by themselves, also without the influence of the user. Neither of these uses of animation serve a function in the user interface, other than perhaps adding appeal to the design. However, they have a detrimental effect on aspects of the system's usability. The compass has text written around the edge at the four compass points (this text is as follows: at the north point -"the guide", at the east point - "website plan", at the south point – "magazine" and at the west point – "winter escapes"). Each of these pieces of text is in fact a hypertext link to other pages of information. This was not apparent until by chance the mouse pointer was moved over the compass and there was a change in the text at the bottom of the browser (the cursor also changed shape). Shortly after the discovery that these compass points were actually links, the lid of the compass closed shut for a few seconds and obscured the text making it impossible to read or aim the mouse at a link of interest (in fact the link can still be selected and the text links or the compass points are invisible). The problem here is that the animated opening and closing of the lid attracts attention to the compass, and then interferes with the user's ability to perceive that the text at the four compass points are indeed links and, moreover, makes it difficult to select, read and aim at the links with the mouse cursor even if the user is quick enough to realise that they are links and wants to select one of them.

It can be argued that this particular use of animation in multimedia ignores a number of desirable features of design. It does not make a significant contribution to the overall quality or ease of interaction with the system, nor does it convey any useful information. Furthermore, it actually prevents the user from exploring the system by obscuring, through the animation itself, some of the navigable links.

[14] Unfortunately, this website (www.scotourist.org.uk) no longer exists at the time of completing this thesis.

Figure 1 Scotourist Contents

The second use of animation is on the smaller star-like compass points that are alongside the text in Figure 1. These are one of the first things that the user notices on the page. They all rotate at the same time and, when viewing the full page with all its rotating star-like compass points, they become very distracting and interfere with the reading of the text and the search for information. The star-like compass points are selectable icons that have the same function as the underlined text links in the adjoining text in Figure 1. This redundancy is useful as it increases the users' chances of finding or noticing something. However, the animation of these compass points has a distracting and interfering effect on the users' ability to read and select items of interest from the text. As with the opening and closing lid, the animation here does not make a significant contribution to the interaction with, or interpretation of, the information. Instead it distracts and interferes with the user's attention.

On the same page (Figure 1) there is a map of Scotland located below the compass. On this particular page, the map is not interactive, whereas on other pages (Figure 2, Figure 3 and Figure 4) it is. In order to inform the user when the map is interactive, the designers insert text under the map (Figure 2) telling the user to “click on a region of the Scottish map for information on that area”. Whilst the text does appear on all the relevant pages, on the contents page the map can easily be mistaken for an interactive feature, and users are likely to still try and select from it, even though the text is not there, and even if they have seen the text previously on other pages.

Figure 2 Scotourist Tour Contents

The map presents further problems when it is interactive. In Figure 2 it can be seen that the map shows regional boundaries representing different regions of Scotland, signifying that regional information is available. Good use is made here of the redundancy and multiple routes for exploration of information as further information about these regional areas can be reached from either the map or the rotating compass points.[15] There are nine selectable compass points, eight of these corresponding to regions of Scotland and the ninth labelled as "practical information". A close look at the map gives the impression that there are five regions on the map divided by the boundary lines – so where are the other three regions? They comprise the Outer Islands, Edinburgh and Glasgow. It is not made clear that the Outer Islands, Edinburgh and Glasgow are regions, and unless the user is from Scotland, they will most likely be unable to identify the names of the other five regions from the map alone. They would have to read the text by the rotating compass points and guess where each of the sectors is on the map. There is a clear inconsistency between the two representations, and for this reason the information presentation on the map itself is of poor quality.

When selecting a region from the map there is no clear feedback from the map regarding which region has been selected. The chosen region is displayed and the map is re-created with the other regions drawn in a lighter shade and grouped together without regional boundary lines (Figure 3). The text below the map asks the user to click on a region of the map (as before) and select a new region, this time without any regional boundary lines. Nor is the user able to make a selection from the hosts of rotating compasses to access another region, because these now relate to features and

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[15] The rotating compass points are here again - nine of them this time, spinning and distracting the user.

information about the selected region. At this point the user can only guess where the regions were on the map, receiving no help from the interface. These design problems can be described as the failure to maintain a consistent use of redundancy and not consistently allowing multiple routes of exploration.

Figure 3 Scotourist Guide – South of Scotland

A further problem is shown in Figure 4. Here the user has selected the “places to visit” page for one of the regions (Perthshire, Angus & Dundee and the Kingdom of Fife). They are presented with an attractive display, including descriptive text and photographic images. The pictures provide high quality information representation and a seemingly natural use of this visual medium. The text contains highlighted locations that can be visited for further information and alongside and below the selectable locations are photographic images. At first glance, this appears to be a good use of redundancy. However, the images are not of the places that can be selected. The top image is of Blair Castle and the image at the bottom of the page is Pitlochry. Both are non-selectable places referred to in the text. Furthermore, Pitlochry is mentioned in the text before Blair Castle, yet the pictures are ordered so that Blair Castle appears before Pitlochry. These are, then, further design problems caused by inconsistencies between links and pictures, and the juxtaposition of pictures that bear no relevance to the text content. This lack of referential alignment between causes confusion and ambiguity.

Figure 4 Scotourist Guide – Perth

2.4 Conclusions

To summarise, the brief analysis of this rich and interesting information system has highlighted a number of points on which the system could be improved. The attempt has been made to take a step back from the detail of the particular design problems and characterise these on a more general level of design issues, in such a way as to identify more generally applicable design features.

Multimedia technology, therefore, offers richer forms of representing information, but does not always increase utility and usability. It allows for the expression of concepts and information more fully, with greater clarity and accuracy, but can also introduce ambiguity and confusion. The challenge is, then, how to gain the benefits whilst avoiding the potential pitfalls.

In this chapter, it has been shown that there need to be principles to support the design and evaluation of multimedia systems. Some examples from a system design have been described illustrating that there is, indeed, a design problem.

The following chapter will show the criteria designers use when employing multimedia in their designs. We will get back to the design features in Chapter 4 where they will be described in greater detail.

Chapter 3 Multimedia Design Decision-Making

"All men by nature desire to know."

Aristotle, Metaphysics

3.1 Introduction

The previous chapter motivated interest in problems associated with interactive multimedia design. The chapter goes on to explore how designers make media selection in their work. It describes a qualitative study of multimedia design decision making, using a sample of eight interaction designers. The study involved interviews with the designers on the criteria they employ when using and selecting multimedia.

Trying to understand interaction designers' decision-making process is not something new, though the literature that examines it empirically is fairly limited (Hassard, Blandford et al. 2009). Hammond and colleagues (1983) for example, concentrated on the use of classes of psychological understanding by HCI professionals. In terms of interviewing designers we can cite studies that involve understanding designers' computing needs and programming knowledge (Dorn and Guzdial 2010b), and requirements for new prototyping tools (Grigoreanu, Fernandez et al. 2009). More specifically, in a study to investigate software engineering general decision-making process (Zannier, Chiasson et al. 2007), it was found that problem structuring is at the core of the process, determining the use of a more natural or a more rational[16] approach to solve the problem.

However, none of these studies covers the specific case of multimedia, which is exactly what this chapter does. Equipping designers with tools, methods and processes requires an understanding of how they make design decisions in real life. Consequently, this study not only aims to motivate the support of multimedia design but also to advance our interpretation of current designers' practice.

To sum it up:

- There is little empirical work in this area
- It is highly relevant to research
- It motivates the development of design and evaluation processes and tools
- It advances interpretation of designers' practice

This chapter presents findings from an exploratory, qualitative study of professional interaction designers. It describes the study methods in detail, its findings, the implications of these findings for research and design, and its links to the following chapters.

3.2 The study

The study set out to understand how designers approach multimedia design by adopting a qualitative research method. This approach provided a naturalistic and rich description for the analysis of possible emerging commonalities.

We accomplished our empirical examination via interviews and thematic analysis. Eight interaction designers were interviewed. All interviews were conducted face-to-face. The interviews followed a semi-structured format and lasted, on average, 65min with a range from 50 to 78 minutes, totalling

[16] "Rational decision making is characterized by the consequential choice of an option among a set of options, with a goal of selecting the optimal option. Naturalistic decision making is characterized by situation assessment and the evaluation of a single option with a goal of selecting a satisfactory option." (Zannier, Chiasson et al. 2007, p. 637)

approximately nine hours of conversation. Interviews were recorded and transcribed for thematic analysis. Lastly we used our results to build an explanation of multimedia design decision-making.

The purpose of the examination is to answer the following research question:

what criteria do interaction designers employ
when making decisions related to multimedia?

3.3 Method

3.3.1 Data collection

Interviewing was selected as the most appropriate method for data collection to encourage designers to reflect upon their work. The choice of interview style was based on critical decision method (CDM) (Klein, Calderwood et al. 1989; Zannier, Chiasson et al. 2007), a technique that relies on interviews with decision makers to examine recent cases of interest. Used to study cognitive bases of judgment and decision making in naturalistic settings, CDM is a retrospective interview strategy that applies a set of cognitive probes to actual incidents that require expert judgment in decision making.

The interviews began with some general questions about design approach to identify some critical incidents - in this case, ones that involved the decision to use multimedia. The interviewer then asked for a brief description of the selected incidents. Then a semi-structured format interview was used to probe different aspects of the decision-making process. The number of critical incidents and the order and the way in which questions were asked varied, depending upon the interviewee's descriptions, but the nature of the questions remained the same.

Questionnaires, ethnographic studies and user diaries were alternative methods that were considered for data collection. They were rejected for being either time-consuming (ethnographic studies), not naturalistic (questionnaires) or difficult to implement (diaries). The use of CDM in combination with interviews, on the other hand, has already been successfully used in analysing decisions by software designers (Zannier, Chiasson et al. 2007); it was found to be beneficial in generating natural conversations with interview participants. Furthermore, it was useful in keeping a consistent approach to all interviews. By focusing upon real situations, it also avoided the idealised, opinion-based world.

3.3.2 Participants

Interviews were conducted exclusively with interaction designers currently[17] working in industry, employed by web/user-experience design agencies (one of the participants works as free-lancer for design agencies). Selection of participants followed a purposeful random sampling to increase the credibility of the results. Twenty-five interaction design companies in Bath, Bristol and Cardiff were identified by a web search, and approached with requests to interview interaction designers.

From the eight participants who took part in the study, four were from Cardiff, two from Bristol and two from Bath. They were all men, working for design agencies that have clients in different sectors of the market giving them a broad range of experience in different domains. This also means that each project they work for has a different set of requirements.

The interviews took place primarily at the time and location most convenient for the interview subject: at his place of business or, when that was not possible, in cafes - we attempted to make the

[17] Interviews were done in 2011

interviewee as comfortable as possible in this regard. All participants signed a consent form (Appendix VV) where they were informed about the confidentiality of their participation. Through a short questionnaire (Appendix WW), demographic data was collected prior to the interview, a summary of which is shown in Table 2.

Table 2 Demographics of participants

Part.	Job/occupation	Experience as interaction designer	Education/background	Setting
1	User Experience Consultant	1 year	BA Cultural and Media studies	Office
2	Lead designer of UX Company	5.5	Self-trained	Cafe
3	Director/web designer	10	BSc Electric and Electronic Engineering + MSc Data Communications	Office
4	Lead Designer	6	BA Graphic Design and Communication	Cafe
5	Freelance UX architect	11	Self-trained	Cafe
6	E-communications coordinator	2	BSc Computer Science	Office
7	UX Consultant	9.5	BA Applied Psychology	Office
8	Freelance UX designer/E-communications coordinator	2	BSc Computer Science	Cafe

3.3.3 Interview

Semi-structured interviews were conducted with each participant; a digital dictaphone recorded these. The questions followed a basic structure, but the interviewer could deviate and employ a conversational strategy where necessary, depending on what emerged from previous responses; this flexible and mixed format allowed some issues to arise through the discussion.

Sample size was guided by the principle of thematic saturation. Basically, “saturation” is operationalized as the point in data collection and analysis when new data produce no new codes (Hoepfl 1997). In the present study, this happened after the 5th interview, and by the 8th interview, data quality showed an adequate answer to the research question (Marshall 1996; Mason 2010).

Before each interview, the interviewer read a briefing about the background and purpose of the study:

> *I’m interested in knowing the way you approach design. I’ll ask you some general questions first and then some more specific ones as I get to know the work you do. Please, feel free to ask for clarification of any points that are not clear. Examples are always good to illustrate some points, so feel free to show me anything that will contribute to your answers. Paper is available in case you need to write or draw (e.g. diagram) anything.*
>
> *There are no right or wrong answers, and no judgment will be made about you, your colleagues or the company you work for. I’m interested in what really happens during design, not what an ideal way design should be. Once again, I remind you that the information you give me is strictly confidential so feel absolutely free to say whatever you want.*

3.3.4 Thematic Analysis

Thematic analysis (Braun and Clarke 2006) was chosen as the method for this study because of its flexibility in finding rich themes at the same time that it provides detailed account of data. Rich themes can be found by induction, i.e., drawn from the data in an unplanned manner that is relatively free from the analyst's pre-conceptions.

Table 3 shows the steps followed from the method. After transcription, familiarisation with the data is essential: reading, making notes following an inductive approach to identify major topics embedded in the data. This is followed by re-reading the data in order to code the interesting features. Codes are then collated into an initial set of themes; this set is reviewed against the codes previously identified. Themes are then revised by re-examining the data, with clear definitions and supporting data. Finally, extracts are selected to illustrate each theme.

Table 3 Phases in thematic analysis (adapted from Braun and Clarke (2006))

Phase	Description of the process
1. Familiarizing yourself with your data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes	Checking if the themes work in relation to the coded extracts and the entire data set.
5. Defining and naming themes	On-going analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts.

More commonly associated with user studies in HCI (Parente and Bishop 2009; Hook, Green et al. 2011), thematic analysis has been used in some studies conducted with designers (Hassard, Blandford et al. 2009; Dorn and Guzdial 2010b; Dorn and Guzdial 2010a).

More specifically, a theoretical thematic analysis was carried out which means it was driven by the research question, and knowledge and ideas about the research question, though all codes were tied closely to the data set.

The themes that emerged from interviews were all based on the interviewee's own description, and not on questionnaires or surveys. By doing that, unexpected data could also be explored, what could have been easily missed by structured methods (e.g., questionnaires or surveys) that are more useful for quantitative methods.

3.4 Verification

It is difficult to assess the reliability of thematic analysis applied to semi-structured interviews. However, in order to assess inter-coder reliability, 12 subsets of the verbatim transcripts corresponding to approximately 10% of transcripts were selected randomly and coded by a different coder that was not present during the interviews.

A total of 38 points were identified by the new coder in these transcripts with an agreement between the two coders of 84.21% (i.e., 32 points were identified by both). These points were then analysed to see if the categories were the same. Agreement was 93.75% (30 out of 32). This rate of agreement was significantly higher than would be predicted by chance: Scott's π = 0.9189 and Cohen's κ = 0.919 (Landis and Koch 1977).

3.5 Findings

In what follows, the interviews are presented and analysed. The major purpose of the analysis was to organise participant responses in such a way that overall patterns would emerge. Each identified theme is illustrated with one or more representative extracts from the transcripts. If necessary, these excerpts are edited for anonymity and brevity.

Table 4 shows the coding of the data. Searching for themes related to designers in terms of criteria for using/selecting multimedia on websites, four core theme sources emerged (Figure 5):

- Business/commercial,
- Designer,
- User/Task and
- Research.

Each of these four theme sources is examined in the subsequent four subsections.

Table 4 Coding

Theme source	Theme (criteria for choosing specific media)	Frequency	Participants (out of 8)
Business/ Commercial	Industry consensus/ Competitive analysis	16	6
	Client decides exactly what they want/ What the client likes	10	5
	Cost/time constraint	8	4
	To persuade	7	4
	Media is already available	2	2
	To sell more design services to the client	1	1
	To keep users on the website for longer	1	1
Designer	Previous experience (as a designer or as user)	11	7
	I (we) know it works/presumed common knowledge/ Intuition	13	6
	It's already decided (by another designer) when it comes to me	3	3
	Lack of skills to use/produce specific media	2	1
User/Task	To support a task	9	4
	To engage	9	3
	To offer more choices to the user/redundancy	6	2
	To support a type of user	1	1
	To increase trust	1	1
	Usability test with colleagues as users	1	1
Research	Information from magazines/blogs/books	2	2
	Evidence from research	1	1

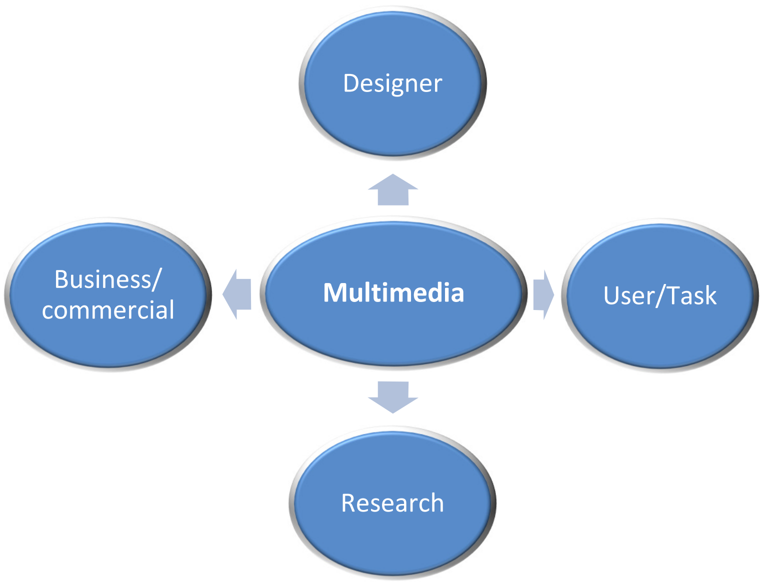

Figure 5 Core sources for themes of multimedia design decision making

3.5.1 Business/commercial

In the data analysis a number of themes emerged, which appear to provide a rich description of business/commercial factors that restricts and at the same time informs what designers do (Figure 6).

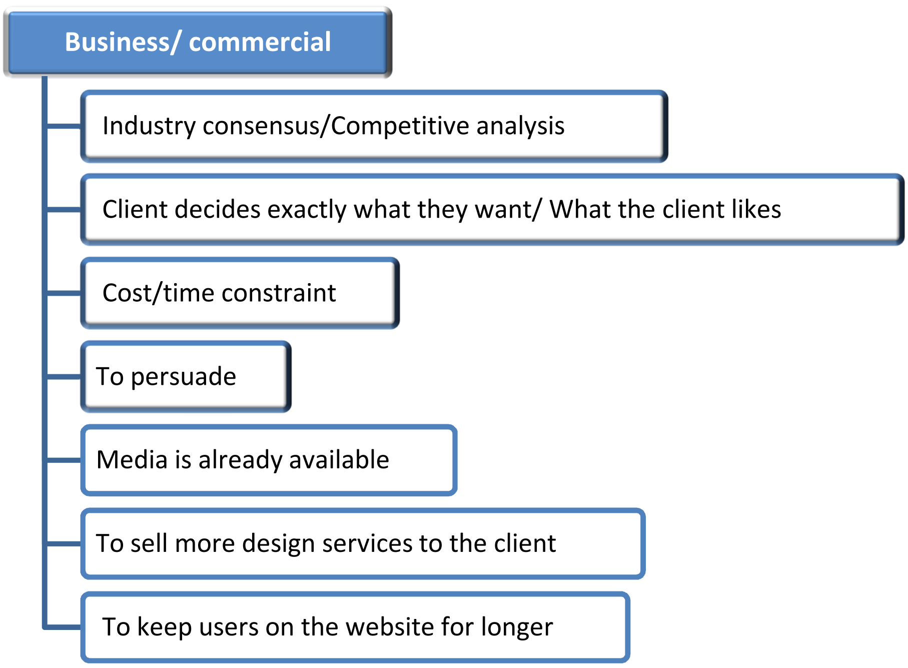

Figure 6 Theme source 1: Business/Commercial

Almost all participants pay attention to designs that are common across the client's industry sector. They purposefully inspect designs from companies that are direct competitors to their clients. Designers try to follow current trends, being inspired by what they consider to be good ideas and avoiding bad ones. This is illustrated by Participant 5 who systematically keeps a library of what he considers to be good examples of design:

> *The first one that comes to my mind is best practice, cause you've seen on other sites. You can't really help it, when you're working in the industry, every time you visit a website, when you see good stuff or when you see bad stuff, you always remember it. … I have a library of many thousands of links and ideas. Whenever I am in a page and I see an interaction that I like, I'll just bookmark it putting a note as good example …- it can be tiny little things or it could be broader. So best practice – stuff I've seen in other websites and made a note of. (P5)*

Participant 3 mentions that his choices are sometimes based on what he sees in other websites, not necessarily from the client's competitors:

> *it might be based on what other people are doing too. ... I have a general awareness of what other sites are using. (P3)*

Specifically, as part of the design process, designers do competitive analysis, i.e., they will inspect websites that are in the same domain area as the one they are designing. This is a clear attempt to get ideas, and to avoid the problems that, in their opinions, other sites have:

> *We also take into account what other websites associated with that particular sector are like so we got a feel for what the general public expect in terms of website experience for that sector – those do change a lot. So we build that in. (P3)*

> *Again competitive analysis to see if a whole range of other clients are using it, competitors to the client, what they do on their websites; if they're doing something right, it must be ok (P4)*

Participant 5 states how important competitive analysis is in his role:

> *I spent two days just doing a competitive analysis of their sites … and produced a document in what I think they do well, they do badly, and what can you nick from all of this to produce the optimum user experience – cause they all do good things, and bad things… So that's just taking well established practices and then just honing them down… competitive analysis is a huge part of what I do (P5)*

In many situations, clients not only have business requirements for what they need, but also impose their own design decisions by being very specific about it or suggesting a preference for a type of media:

> *… that was basically what they (client) said is "we want to have video on these", so we had to figure out where that could go, how it would work.…they (client) provided the video…. we didn't really questioned to be honest… They just wanted to put those on the site. (P2)*

> *… you are working with the clients…– they will say to you "on our case study page we've always got a video of the case study, and we always got five images to show the most important, we've got this much copy about the case study , there's a pdf if you want to download ". They will give you this content and will tell you "this is what we want to show about the case study" and how you present it online. So in that respect I'm not necessarily deciding what media to use on the page… They give the content and it's up to you to make it the best use for the user. (P5)*

Designers realise that ultimately many decisions are taken by the client, and they will have to compromise:

agencies are very keen to keep their clients happy … I have a lot of arguments with the end-clients cause I'll say "this is a benefit for the user" and they'll say "we don't care, this is what our shareholders want, this is what our managing directors want, or this is what our internal focus group want, we have to get this content on the site somewhere" – and I'll often sit there and say "this content doesn't suit the purpose of anything other than your shareholders"… [this happens] all the time, in every project, it is very rare that it doesn't happen. … . . And I'll push things and I'll put forward "this is what I think is best for the user" … but they'll be vetoed, I can say to you. …You have to be pragmatic unfortunately. (P5)

Designers are not always involved in project planning and they will have to do what is possible with the amount of time and the budget allocated to the project. In situations of pressure, this means their choices will be restricted:

Realistically I've got all those filters of time-scale, costs and everything else. … and I've got to make sure that I can do whatever I do in the timescale. Sometimes it runs over and I have arguments with my account manager saying "oh, I can't do a decent job within a certain amount of time unless you want me to compromise". (P4)

we were told to take it out because they can't have that video for all their [products].… while these things are really nice we often avoid them because of cost. Again we know the client won't pay for it, we know it'll take ages to make. …That's often the problem for most of our more exciting, interactive elements of any of our designs that we do is down to time or cost that we can't do them (P2)

In certain situations, multimedia content is seen as a persuasion tool:

This (video)… stuff is quite emotive and we were very keen on using story telling as an approach, you know, it's very persuasive (P7)

I thought we could really promote great ideas really quickly without having hundreds of words – I think that's one of the benefits of video – you can portray a lot in a very short amount of time. (P2)

in this specific page where we're trying to make it clear why it is important that you (the user) work with us (the business), we're just taking this approach of … different forms of media. (P7)

it (video) does have a real-world impact by engaging them … it can help them engage with your message more. (P6)

When media is already available, the decision to use it does not involve any constraint of cost or time usually associated with media that has to be produced:

We've got our pictures from [the client] for that, mostly because they have some fantastic photography, all the product images they have thousands of pictures of [their products] already. (P2)

they (clients) had some videos anyway… they already had ones. … so this is something they've done (P7)

Media can also be used to sell more design services to the client or as a strategic tool to keep users on the website for longer:

We don't tend to do many interactive illustrations or diagrams but it's also something we're trying to push – it depends on the budget basically…We're trying to push to get people to buy into. (P4)

[We are] trying to get more clients to use video as well online, to do show reels, presentations, when you show a video to somebody it takes a little more time on the website they'll be on the site for longer, the more likely to go ahead and look around the rest of the site if a video is in there, so it's one of the things we are trying to put in, and trying to push at the moment is video content." (P4)

These quotes illustrate the fact that most of the time designers do not have all the freedom and time to create multimedia solutions with user experience as a high priority goal. They are constrained by business requirements coming from clients that, more often than not, make their own design decisions. Commercial factors, such as budget and time for the project, limit what designers could potentially achieve. Moreover, they resort to solutions that competitors have achieved, as a way to please their clients, to stay up-to-date with the industry and to save time.

3.5.2 Designer

The thematic analysis revealed a pattern of participants reporting designer-related reasons for choosing specific media. Designers utilise their accumulated experience, knowledge, and also intuition when dealing with design decisions (Figure 7).

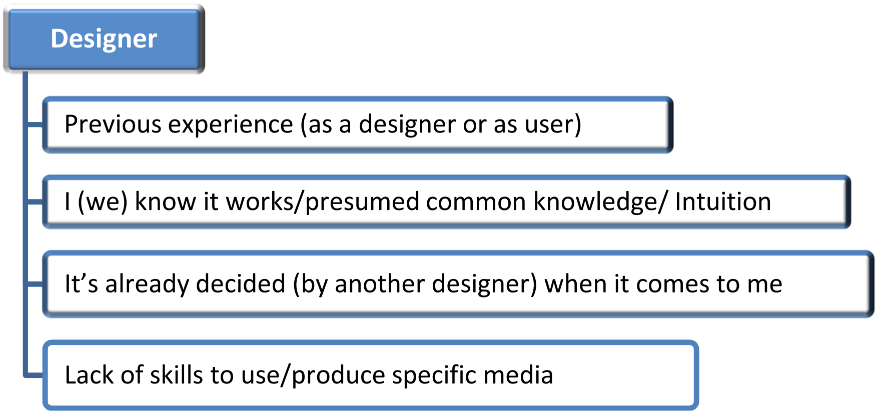

Figure 7 Theme source 2: Designer

Previous experience either as a designer or as a user of other websites seems to be an important factor when designers decide to use and select media, as illustrated by these extracts:

It's based on experience and …. I have a general awareness of what other sites are using (P3)

In terms of deciding "is this media appropriate for this job", again it comes down to experience since I started working basically. … I use other websites, smartphones, …, and through use you pick up ideas. (P4)

(decision is based on) what has worked in the past, and what hasn't worked in the past. (P6)

perhaps you've tried something in the past that did or didn't work and you look at that and see if this is comparable to the situation – it might not work in that case but maybe in this, because the message is different or the audience is different. (P7)

experience …and from other websites we've done this sort of thing and websites we use as well … like I said, experience (P8)

Some designers even admit that they cannot explain how they reached certain decisions mentioning intuition as an explanation or referring to it as something that they know works or that is an established common knowledge:

> *you know what works and doesn't work. (P4)*
>
> *you just know what's right. (P5)*
>
> *It's based on … feelings, gut reaction, intuition … I must admit that I tend to go with gut reaction … in practice a lot of it comes down to rule of thumb and gut reaction in the way we do design things. (P3)*
>
> *it's an informed best guess I suppose. (P7)*
>
> *a sort of a bit of common sense. (P8)*

In certain situations, the designer feels powerless and does not have an input on the decision. It is already decided by a project/account/marketing manager or another designer when it comes to them.

> *A lot of that is covered in the wireframes as well, so this is before I really get my hands dirty, so one of our usability analysts would be working on those. (P2)*
>
> *to a point, it's not down to me to make these decisions cause I get the brief or proposal from the account manager – if there's an account manager on board, they'll tell me what's needed. (P4)*
>
> *often that is out if my hand. … somebody else is often doing that job, it's a designer or a marketing manager or someone who makes that decision about the image or the video, or the style … but more often than not you know you might not be involved in that process. (P7)*

Even when designers believe that a specific media is best for a specific situation, they sometimes have to compromise due to lack of technical skills in the team to build it:

> *it was something that we really would have liked to have done [to use interactive animations]… (but) we wouldn't even be able to comprehend how to start making that. (P2)*
>
> *we don't deal a lot with video production so we try to avoid that if possible. (P2)*

Designers do not make decisions in a vacuum – they rely on their previous experiences and on what for them is common sense or simply intuition. Certain decisions come very naturally to them and it becomes difficult to explain their rationale for that. In other situations they have no alternatives of media to consider as they are given a precise choice made by someone else in the team. Finally in some situations they are not able to make design decisions for lack of technical skills in their teams.

3.5.3 User/Task

A third theme source that emerged is related to supporting either users or tasks (Figure 8).

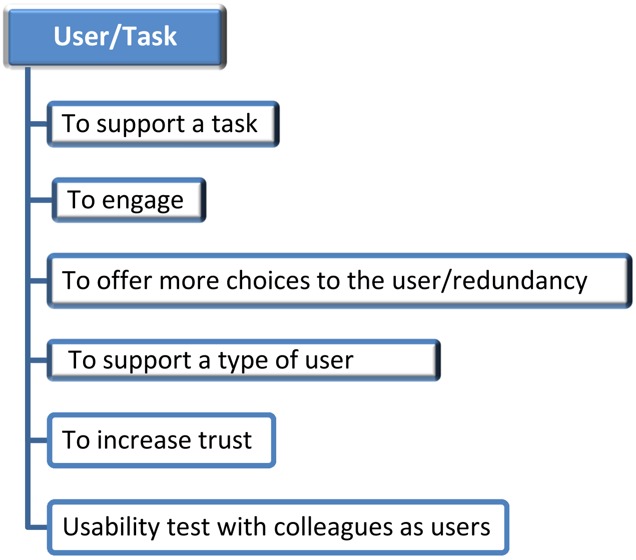

Figure 8 Theme source 3: User/Task

In trying to support tasks, Participant 5 uses a video to help new users to a website, while Participant 10 uses it to facilitate sharing of messages:

> *There are instances where I'd say use a video. For instance, the first time a user enters a site … they benefit from just being told how to use it the first time. … you can just do a quick screen capture where someone says "use this site, click here, click there", and you can just post it. You can say a lot more in a video. (P5)*

> *(use of video) It's encouraging people to go on to the next step of whatever we wanted to do. So it was setup to be very easy to share. That's one of the things we wanted people to do – to share a message (P10)*

Participant 6 designed a website that uses videos as a way to engage people in order to attract new volunteers – so the design made it easy to share the videos in social networks:

> *The reason I wanted a lot more multimedia for the online stuff was because that's the best way to engage people online…. So it does have a real-world impact by engaging them, and if they are not supporters, but they're just generally interested, it can help them engage with your message more. … a lot of people use press releases as news items on websites and it doesn't work, doesn't engage with anybody, and they switch off after 2 minutes. (P6)*

Participant 7 says people respond better to images:

> *certainly at the design stage and certainly in the pages where you are trying to engage people, we use a lot of imagery because to engage people, you know – people respond better to some of the images (P7)*

By using different media to communicate the same information, designers hope it offers more choices to the user:

> *only relying on say just a video, or just normal content… you run the risk of not engaging some users and obviously we are trying to do something that can avoid that. Some people simply won't watch videos, you might be in a noisy office, you might not have headphones… it could be some people are more predisposed to watch videos. Ultimately we are trying to serve the same content … you're trying to*

provide a content that is there in their favourite format … just in slightly different ways. (P7)

I'd say a mixture of all of them. (types of media)… And you'd let the user choose basically.… You give them the option: you just say "these are the media to see this content" and let them decide…. you customise … how do you want to access the information… you can have the same story through three different media – video, text, podcast, as long as he gets one of those, and they respond, then job done. You offer redundancy basically: you're doubling upon the information you're providing (P4)

By providing different types of media for the same content, different types of users can be supported:

It will cater for more types of users, what their preferences might be. (P4)

In certain situations, media is selected to increase trust. Participant 4 used talking-head videos to explain the services provided by the client's company – according to him, this was the reason the number of visitors to the website increased:

we got a client … we introduced talking-head videos from the key members of the board explaining their services which is quite engaging …so it'll let the user see who it is they're dealing with. They're talking about their subject matter, they're knowledgeable, you start introducing elements of trust with the business, and they appreciate - they've seen a boost in the visit numbers. (P4)

One of the few accounts of usability test used in design was given by Participant 5 - actually the usability evaluation he refers to was done around the agency with work colleagues acting as participants, in an informal way:

I don't always jump straight into html prototyping, I'll do some low fidelity prototyping just sketching out … "how about this for presenting this UI elements in a page, is it too busy or"– I'll do some quick usability testing around the agency and say "where would you expect to find this content" – this with colleagues. (P5)

In a different example Participant 8 recognizes that they do not involve users - this seems to be more the norm than the exception:

we don't ask users, really (P8)

There are some interesting accounts of user-centred design where users and tasks form the basis for the choice of media. Nevertheless, budget and time constraints preclude designers to do user research.

3.5.4 Research

Designers try to keep up-to-date by reading magazines, blogs and books in order to inform certain design decisions.

Figure 9 Theme source 4: Research

Participant 4, for example, emphasises that he wants to keep current with new technologies:

> *I also read magazines and things from the industry highlighting technologies that are coming on board. (P4)*

Evidence from research done previously is acknowledged explicitly by one of the designers:

> *I don't have a background in psychology, but I do try to bring that in … just simple stuff really … people can associate or have a stronger link with visual imagery than they have with text, or in terms of copyright, people scan only half page (P5)*

Findings from HCI research do not seem to be a high priority for designers.

3.6 Discussion

The information-richness of the cases described in the interviews generated many insights related to the original research question of this chapter. Based on the frequency of factors mentioned by designers (Table 4), we can observe some patterns. The factors that lead designers to make some important decisions related to multimedia are mainly related to business/commercial needs/wants:

- Industry consensus and competitive analysis
- Clients that have already made design decisions or that have strong preferences
- Cost and time constraints
- Persuasion for commercial reasons

On top of these factors, designers have their particular reasons to make design choices based on their:

- Previous experience (as a designer or as a user)
- Intuition, when they just know it works

A factor related to user-centred design is also considered:

- Supporting a task

Designers tend to put less emphasis on evidences from research, advice from books, usability/user-experience evaluation, supporting different types of users, offering more choices, engaging users and increasing trust. Crucially for this thesis, considerations of users appear to be absent from designers' criteria.

Other factors can influence design decisions like availability of media, the attempt to sell services to client and lack of technical skills.

The fact that most of the criteria are related to commercial and business goals is not entirely surprising, after all most of the websites described in the interviews are built to generate a profit, and clients are in a position to understand users of their websites (at least they think they are). Also there is a general sense that they should somehow conform to industry standards: if competitors' websites seem to be good, they tend to heavily influence designers' decision-making.

One of the main criteria related to designers themselves are their previous experiences. In this case they make analogies to situations they have experienced before, and select a solution that they know will work.

Considering the main factors that drive designers' choices, one of the consequences is that no design alternatives are generated. Once they are happy with a satisficing solution, they do not try and generate alternatives. This is also connected with what they report as intuition when they do not know exactly why they make certain decisions.

According to Hassard and colleagues (2009), decisions that are taken under time pressure in dynamic environments tend be more of naturalistic based where designers use shortcuts to reach a passable design decision. Based on interviews with 25 software designers, Zannier and colleagues (2007) state that software designers "often use satisficing and singular evaluation in trying different approaches to design", which seems to be the case of interactive designers in relation to multimedia. The first implication then can be stated:

- **No design alternatives generated**

A consequence of that is expressed by one of the participants in the interviews; after stating that competitive analysis plays a major role on the way he makes design decisions, P5 concludes "*I don't know, maybe I'm not an innovative designer (P5)".* Therefore another implication is:

- **Lack of substantial innovation**

Published knowledge and findings from research or even books are rarely consulted. This supports the use of intuition and experience as one of the main criteria when making design decisions.

- **Low awareness of research-based findings**

As argued by Hassard and colleagues (Hassard, Blandford et al. 2009), when interaction designers over-rely on a single initial analogy connected to a previous experience with no input from research based findings, they run the risk of compromising the entire design cycle with an inferior design solution.

There is strong evidence from the literature that generating alternative designs at the prototype phase – known as parallel prototyping – produces better, higher-quality design results (Tohidi, Buxton et al. 2006; Dow, Glassco et al. 2010; Dow, Fortuna et al. 2011). This can be explained by the fact that when more than one design alternative is created, the decision-making process moves towards a rational process, increasing the chance of producing a better design (Zannier, Chiasson et al. 2007).

Design fixation (Hassard, Blandford et al. 2009) can explain why over-relying in an initial idea can override the evaluation of alternatives. Designers utilise cognitive shortcuts due to environment pressures to quickly reach a design decision which could potentially create a design that is not ideal, as designers are not aware that they tend to fixate.

One way to alleviate these potential problems is to involve the user in all phases of the design and evaluation. This is not something new: ideas of early focus on users and tasks, empirical measurement and iterative design have been around for a while (Gould and Lewis 1985), but somehow are still overlooked by designers. And even if they find them useful in an ideal world, designers find it difficult to incorporate them during the design process due to high costs and time constraints.

An alternative approach is to equip designers with principles that support the use of multimedia technology. Principles that could help designers consider different ways to use media according to what they want to achieve. And this is the approach taken in this thesis. Of course, as shown in section 3.5.4, there is a risk that designers will dismiss research-based findings. Although this is a possibility, it is not the focus of this thesis to examine issues of training and capability

3.7 Conclusions

This chapter identifies factors that professional interactive multimedia designers take into account when they make decisions about multimedia. By trying to understand how they make these decisions, we can start to comprehend how it connects to the problems raised in the previous chapter. The method of choice, semi-structure interviews with designers using critical decision method and thematic analysis, offers an information-rich description of how designers make such decisions.

Interview-based qualitative studies come with their own limitations. Despite the fact that rigorous methods were used in all stages of this study, it is not possible to prove that it is 100% externally valid and generalisable. By demonstrating the reliability of data collection, transcription, coding and data analysis we are confident that the results shall prove to be valid in future validation studies.

From the themes identified in this study and their frequency and emphasis, it is possible to see that designers face a difficult situation where the pressure coming from clients in terms of their requirements, desires and impositions is a constant reality that the practitioner has to face. Combined with time and budget limitation, they work in an environment that is highly demanding and challenging, where previous experience and competitive analysis inform design decisions. It is understandable then that the involvement of users becomes a rare occurrence, and that their choices lack research-based criteria that take into consideration human cognitive capabilities and limitations.

By providing designers with tools for thought in the form of design features, it is hoped designers can use this knowledge to better inform decisions on how and when to use different media based on their effect on human cognitive abilities. This way, designers do not rely exclusively on their experience and competitive analysis. One possible use of the multimedia design features is to facilitate the generation of design alternatives.

The next chapter describes a set of multimedia design features that aim to support multimedia design decision making.

Chapter 4 Multimedia Design Features

4.1 Introduction

Having examined the problems with multimedia solutions (Chapter 2) and the criteria designers use when employing multimedia (Chapter 3), this present chapter develops a set of design features that can subsequently be used to guide and inform future designs. These features (that are seeds for design principles) were identified through examination of designs, research outcomes, and theories. After presenting and describing these features, questions for further research will be posed.

4.2 Multimedia Design Features

In this section, a set of interactive multimedia design features are introduced. Each feature is explained and considered together with further questions being raised. The ultimate goal of this work is to develop a small set of principles that can be used to aid and guide designers in their reasoning about multimedia systems.

First we need to understand what the term "principles" stands for. "Principle" is used in different ways in the literature. Shneiderman and Plaisant (2009) differentiated three kinds of guidance for designers:

- high-level theories and models, which offer a framework or language in which to discuss issues that are independent of application;
- middle-level principles, which are useful in creating and comparing design alternatives, and
- specific and practical guidelines, which provide reminders of rules that have not been covered by designers.

For instance, one of these middle-level principles is "Use the Eight Golden Rules of Interface Design" which are eight design recommendations (e.g. "enable frequent users to use shortcuts"). This is in line with their statement that "the separation between basic principles and more informal guidelines is not a sharp line". Yet Preece, Sharp et al. (1994) considered a principle as a special form of guideline. For them, there are two kinds of guidelines: high-level, guiding principles and low level, detailed rules. They considered principles as guidelines offering high level advice that can be applied widely (e.g. "know the user population"). On the other hand, principles and rules were considered to be synonyms by Baecker, Grudin et al. (1995), who defined them as "collections of statements that advise the designer on how to proceed (e.g., 'know the user')", whereas guidelines were defined as "collections of tests that can be applied to an interface to determine if it is satisfactory (e.g. 'provide an average response time of less than one second')".

Here, a principle is taken to be some established fact that has a theoretical and empirical basis for its acceptance, and can be applied to a prescribed problem area in a clearly defined manner, and for which there is some indication of what the result of following the principle (or not) will be (Johnson and Nemetz 1998). A number of areas have been identified where this researcher believes there is scope for developing a more principled understanding of interacting with multimedia, and what features a set of principles for multimedia design must address. These are developed further below.

Naturally, the HCI principles and guidelines that apply to general interactive systems still apply to multimedia systems. Consistency, for example, is believed to help users learn an interface, as the controls, command names, and layout follow a familiar pattern (Sutcliffe 2003). In this case, consistent use of media to deliver messages of a specific type can help by cuing users with what to expect. Therefore, the specific case of multimedia is of more concern here, and the aim is to complement, not to replace, HCI general principles and guidelines.

The remainder of this chapter presents the areas in which there is a need to develop a more principled understanding of interacting with multimedia and what the features might be that an underlying set of principles for multimedia design should address. These areas presented here are the results of a literature survey, the main source being the work by Alty (1993), who has developed design guidelines for the use of multimedia in process control interfaces. Some of the features are particular to multimedia, whilst others apply more generally to wider areas of HCI. There is also a degree of overlapping between the features. For example, two related features are naturalness and redundancy: naturalness can be achieved using redundancy. In the next sections, each interactive multimedia feature is presented followed by prior work that motived its inclusion in this chapter.

4.2.1 Feature 1: Naturalness and Realness

Multimedia systems try to take advantage of human senses to facilitate human-computer interaction, and human-human, computer mediated communication (Nemetz and Johnson 1998b). Considering that we live in a world of multimedia events (Petersen 1998), “many people believe that multimedia communication is natural and corresponds more closely with how the brain has developed” (Alty 2004, p. 49-2), and, therefore, multimedia exercises the whole mind (Marmolin 1991). This is often associated with the development of the human brain, where the processing of input from different channels in a multisensory environment was crucial for human survival. Thus, “the processing of the human brain has been fine-tuned to allow simultaneous sampling and comparison between different channels” (Alty 2004, p. 49-2). Multimedia systems have the potential to make appropriate and efficient use of human perceptual and cognitive capabilities, by making our interaction with computers more natural and/or real, and thus enriching our experience with computer technology (Sutcliffe 2003).

Gibson (1979) argued that our senses are not limited to handling simple stimuli and that in fact our organs of perception are constructed to cope with very complex flows of information in natural environments (Marmolin 1991; Hoogeveen 1997). Gibson argued further that we are not passive receivers of information. Instead, our perceptual system is characterised by the picking up of information and by the integration of activities through different senses. Marmolin (1991) and Hoogeveen (1997) stated that these arguments are relevant to multimedia systems: information systems that need to support human information processing effectively should make full use of human perceptual and cognitive capabilities, should represent natural information flows to users and offer support to process these information flows.

According to Marmolin, complex, dynamic and integrated representations of information are necessary to utilise all the capabilities of the mind. This claim appears to suggest that for a successful multimedia approach it is enough to use a rich set of media to represent information in a more life-like and vivid way. However, Marmolin’s claim is not always valid, as can be seen by conflicting conclusions reached by researchers (e.g., Dillon and Gabbard (1998; Liao 1999), some saying that multimedia is good for users, others saying that it is detrimental, and still others saying that it has no effect on users’ performance. Even though Marmolin’s claim cannot be validated, it is necessary to restrict it to situations where users might be expected to benefit from the utilisation of all the capabilities of the mind[18]. If the context is not considered, there will be a risk of information

[18] In some situations, the use of certain media can hinder the user’s performance. The following section on Media Allocation describes these situations in more detail.

overload (Alty 1991; Faraday and Sutcliffe 1997; Johnson and Nemetz 1998) or unnecessary complexity (Faber, Meiers et al. 1991; Weiss, Knowlton et al. 2002).

Related to naturalness is the concept of realness, or the degree of correspondence between the representation and the real thing. Naturalness and realness are similar to a degree. Naturalness is concerned with the mapping between the stimuli and the senses, recognising the fact that people normally gain information from the world from multiple senses (e.g. hearing an explosion would cause people to look for a cloud of smoke or flames) (Gibson 1979). In the previous example, on the other hand, realness is concerned with how closely the representation of the explosion corresponds to an actual explosion.

Sutcliffe (2003) observed that the degree of correspondence between a multimedia application and the real world is determined by the domain and the tasks the users carry out. Media, like speech and haptic interaction, increase the naturalness of the interaction, but they should only be used when necessary (speech processing requires complex natural language processing, and haptic interaction is only necessary for physical tasks). For instance, in an application where archaeologists use computer generated representations of an archaeological site, a vivid presentation of information has the potential to enhance our understanding of the environments in which our ancestors lived (Chalmers 2002). In order to reconstruct and visualise features of archaeological sites, the representation should look “real”, representing a physical environment accurately and faithfully.

One consequence for systems that possess naturalness and realness appears to be that they show properties of believability (the closer they are to the real thing, the more believable they appear to be). Alty (1993) reporting on multimedia design in the process control area, found that multimedia opens up the possibility of connection to real events, increasing the level of believability. For example, when the operator of a nuclear plant sees a red light changing to green on the control panel he knows that a valve has been opened, but because it could be a system error caused by something else, he is not 100% sure. With a multimedia approach, the operator could actually watch and hear the valve opening, significantly reducing his uncertainty (Alty 1993). Alty argued that media, in particular video, pictures and audio, carry information that can be valuable in human decision making, when it can be crucial to see or hear the real thing. In experiments using decision-making tasks (e.g., choosing a house to rent), Gonzalez (1996) concluded that animations that were based on realistic graphical representations, rather than on abstract images, resulted in more accurate decision making. Moreover, the use of realistic representations made users more satisfied.

A further aspect of naturalness and realness is that of fidelity (degree of detail). Fidelity is a function of the task, information type, user and media. It is important to distinguish between “physical fidelity” and “functional fidelity”. For example, physical fidelity considers how closely an animation resembles the real world, whereas functional fidelity refers to how closely the animation behaves like the real world object and the mapping of control and manipulations (Steuer 1992). Functional fidelity is also known as “behavioural realism” (Lessiter, Freeman et al. 2000). In virtual reality, the naturalness/realness feature is essential for a natural engagement (Sutcliffe 2003), where the user should ideally be unaware that the reality is virtual, whereby physical and functional fidelity are necessary for this to happen. A high level of fidelity is not always efficient and can lack effectiveness (Weiss, Knowlton et al. 2002). For example, in the case of cartoons, caricatures serve the specific purpose of exaggerating or distorting the appearance of someone, and they do not need high degrees of detail. In the educational field, especially for novice learners, a low fidelity environment can be more effective than a high fidelity one, depending on the learning task, as shown in the studies by Harp and Mayer (1998) and Gulikers, Bastiaens et al. (2005).

To fully understand and exploit the naturalness feature, a better understanding of how our senses are affected by each medium and by their combination is required. Moreover, it is necessary to consider when and to what degree particular levels of naturalness and realness need to be attained, in order to support appropriate levels of believability and fidelity. A flight simulator might require high degrees of naturalness and realness, in order to train the pilot effectively. The system must be as believable as the real thing and be of high fidelity to allow the appropriate levels of flying skills to be developed in the pilot. Similarly, in image guided neurosurgery the surgeon must have high degrees of naturalness and realness in the brain images that are guiding him/her as she removes a brain tumour. Both the fidelity and believability of the images are of extreme importance to the success of the operation.

Given the issues highlighted above, the implications of the naturalness/realness feature can now be addressed. Naturalness and realness have been recognised as important components for the sense of presence in virtual reality research (Witmer and Singer 1998; Lessiter, Freeman et al. 2000). "Presence" is a multi-dimensional concept that is characterised as the sense of being in a place (Steuer 1992). Consequently, it follows that a higher degree of naturalness and realness will impact positively on presence. If presence produces experiences that are close to real life experiences (Steuer 1992), then proportionate similar effects could be expected, i.e. in the same direction but of lesser magnitude. Taylor and Thompson (1982) claimed that direct experience has a strong impact on the acquisition of attitude, although it does not affect changes in attitude. Furthermore, direct experience impacts on the way we process information, and it can be presumed that a higher level of naturalness and realness will affect information processing. As Nisbett and Ross (1980) stated, "A picture can be worth a thousand words, and real life exposure to the object can be worth many thousands more" (p. 54). However, it does not follow that designers should always increase the levels of naturalness to improve user interaction, as remarked previously, and doing so without caution can even make interaction less effective.

The whole research area of multimodal user interaction also relates to naturalness and realness. Being able to use a pen, gestures or speech to interact with a system will allow users to use the modality he/she prefers for the task in hand (Roew and Jain, 2005).

4.2.2 Feature 2: Media Allocation and Combination

How, and on what basis, is a particular medium selected for the presentation of a particular piece of information? How can media be combined so as to support and not hinder the users' tasks? These questions are of primary significance to the user-experience of multimedia systems.

Several factors have been recognised by researchers that affect the decisions a designer must make. These are: the types of information, the characteristics of the media, and the characteristics of the users and their tasks (Figure 10). In other words, a better understanding of the information's characteristics, its relation to the characteristics of the media, and the identification of users and tasks, will help multimedia developers to make critical decisions (Heller, Martin et al. 2001). This subsection is organised around these factors, and it concludes with the mapping of information types into media, taking into account users and tasks.

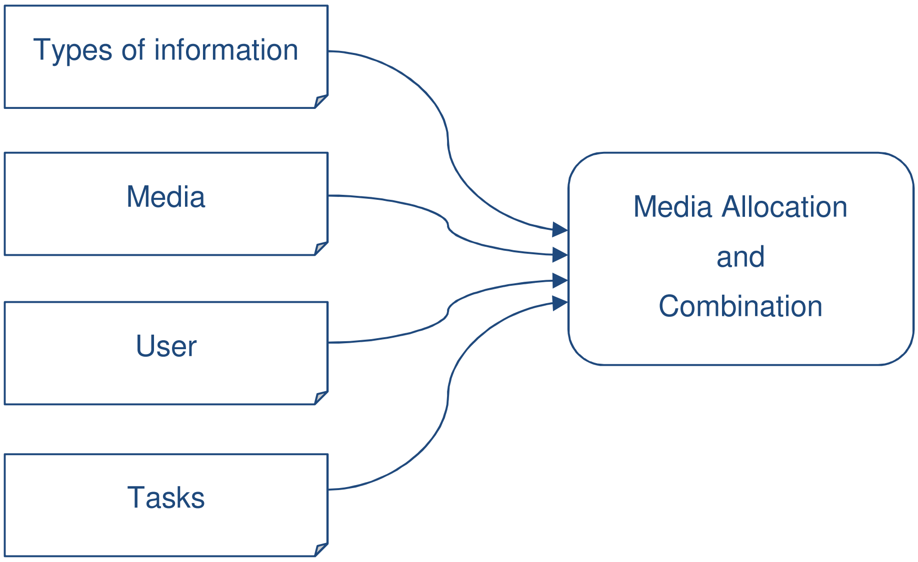

Figure 10 Media allocation and combination

4.2.2.1 Types of information

The type of information is of fundamental importance to the problem of media allocation. Sutcliffe (2003) defined information types as "amodal, conceptual descriptions of information components that elaborate the content definition" (p. 119). The author suggested that, once defined, information types can be mapped into media types.

Multimedia research has focused remarkably little attention on the information content (Schar and Krueger 2002). This could explain why some results from experiments have been contradictory (Hede 2002), as media are selected without any consideration to the information type. As a consequence, some studies have found the selected media to be effective, and some to be less effective. To avoid this, designers should consider the characteristics of the information content, as some media are more associated with representing certain kinds of information than others (Arens, Hovy et al. 1993).

How can the general information characteristics critical to multimedia design be identified? How can the unique properties of different types of information across many disciplines and applications be defined and characterised? Is there any existing classification that can be used for multimedia development? Although recognised by several researchers in the field as a great challenge (Heller, Martin et al. 2001), a definitive information ontology for multimedia design, if achievable, is still to emerge. Nevertheless, certain common elements are gradually beginning to appear. For instance, the basic classification of information as being physical/concrete, or conceptual/abstract is common across several ontologies (Roth and Hefley 1993; Alty 1997; Heller, Martin et al. 2001; Schar and Krueger 2002; Sutcliffe 2003; Alty 2004).

One of the most comprehensive ontologies of information types was given by Sutcliffe (2007) (Table 5). Sutcliffe's categorisation identified characteristics that impact on the effectiveness with which a given medium expresses information (Heller, Martin et al. 2001). "Information" was classified as physical or conceptual, static or dynamic, and then by the type of content (e.g., states, discrete action, procedures). Physical information includes physical objects, persons, and places; conceptual information includes abstract concepts such as freedom and love. Static information remains stable in its context, e.g. states, descriptions, concepts and facts. Dynamic information is not stable over time, but refers to interactions between certain variables or factors, e.g. processes which can be described as a sequence of steps necessary to accomplish a goal, solve a particular class of problems, or produce a product . It is important to note that Sutcliffe's ontology has its limitations. For example, it does not cover the notion of time, in the sense of distinguishing actions in the past, from present or future. It also fails to deal with intentions ("I am going to…", "the goal is …") and probabilities ("It might rain" v. "it will rain"). Nevertheless, it should not be dismissed for not being useful for the purposes of media allocation. On the contrary, it is a valuable resource and has proved to be sufficient for the purpose of the present work.

Table 5 Information type ontology and examples (Sutcliffe 2007)

Abstraction from the real world	Change in time	Content	Example
Physical	Static	States	Current state of the weather
		Descriptions, attributes	Features of a personal computer
		Relationships	Similarity between twins
		Spatial	Dimensions of a room
	Dynamic	Discrete action	Turning a computer on, switching light on
		Continuous action	Ski turn
		Events	Start of a race
		Procedure	Clear a paper jam in a photocopier
		Causal	Rainstorm causing floods
Conceptual	Static	States	Declared peace
		Descriptions, attributes	Person's belief
		Relationships	Classes of religious belief
		Values	Prime numbers
	Dynamic	Discrete action	Choosing to agree/disagree
		Continuous action	Monitoring, problem solving
		Procedure	Diagnosing a fault
		Causal	Explanation of gravity

Selecting the way to convey information does not only depend on the type of information. In cases where more than one medium and more than one presentation technique could be used, other factors will determine the final decision (Heller, Martin et al. 2001). The media, user characteristics, and the tasks that multimedia is designed to support are important issues as well.

4.2.2.2 Media

Each medium has both constraining and enabling features (Arens, Hovy et al. 1993) and affords different interactions, offers different communicative intentions, and has its own rules, biases, capabilities and conventions (Oren 1990; Johnson and Nemetz 1998; Heller, Martin et al. 2001). Each medium serves a different purpose and is more or less adequate and effective in conveying different types of information and achieving different communicative effects. Several researchers have attempted to classify media in a variety of different ways (Arens, Hovy et al. 1993; Heller and

Martin 1995; Bernsen 1996; Bernsen 1997; Vetere, Howard et al. 1997; Sutcliffe 2007). What follows is a synthesis of the main findings.

The classification proposed here (Table 6) extends to that of Sutcliffe (2007), with Bernsen (1996; Bernsen 1997) and Heller and Martin (1995) also being influential. Sutcliffe's classification focuses on the psychological properties of the representations (e.g., relationships, states) rather than the physical nature of the medium (e.g., digital or analogue encoding in video). Bernsen's taxonomy, part of his modality theory, makes a distinction of the modality[19] of communication (vision, hearing and touch), which is not part of Sutcliffe's classification. To the realistic and non-realistic distinction made by Sutcliffe, Heller and Martin introduced an intermediary category, here referred to as semi-realistic[20].

The use of Bernsen's modalities of communication increases the complexity of Sutcliffe's taxonomy. In order to reduce it, a simplification is made by combining static and dynamic acoustics, since acoustic modalities are mostly dynamic (static acoustics, such as an alarm signal, constitute a small fraction of acoustic representations (Bernsen 1996; Bernsen 1997)). Moreover, haptic modalities are mostly static, so they are fused with dynamic haptic modalities, in accordance with the taxonomy of Bernsen (1996; Bernsen 1997). Bernsen (1997) admitted that borderline cases do exist, although they are relatively small in number.

[19] It is important to observe that in Bernsen's theory, a modality is a mode of representation, rather than a sensory modality as in the psychological use of the term.

[20] What is called here semi-realistic, Heller and Martin (1995) called it representation.

Table 6 Media taxonomy

			Realisation (graphics, acoustics, haptics)	Example
Realistic	Linguistic	Static	G	Fully rendered letter
			H	Taping Morse code on the back of a person
		Dynamic	G	Subtitles in a foreign film
			A	Speech of a politician
	Non-linguistic	Static	G	Photograph of a dog
			H	"drawing" a flower on a person's back with a finger
		Dynamic	G	Video of a waterfall
			A	Recorded sound of a dog's barking
Semi-realistic	Linguistic	Static	G	
			H	Static object in a virtual environment
	Non-linguistic	Static	G	Edited photograph with added and/or removed details
		Dynamic	G	Animated model of a laptop computer
Non-realistic	Linguistic	Static	G	Dialogues in comic strips
			H	Braille
		Dynamic	G	Dialogues in animated cartoons
			A	Read aloud stories
	Non-linguistic	Static	G	Drawings from a comic strip
		Dynamic	G	Animated cartoon; animated model of electricity
			A	Synthesised noise sounds

Realistic, semi-realistic and non-realistic media

Realism in media is placed in a continuum from realistic to non-realistic media. Realistic media are captured directly from the real world (e.g., photographs, videos, natural sounds) (Sutcliffe 2007); they are concrete, natural, fully explicated expressions of information. Different researchers have called realistic media by different names: Purchase (1998) called them concrete media, whereas Heller, Martin et al. (2001) called them elaboration media. For Bernsen (1996; 1997) they are analogue media, and for Arens, Hovy et al. (1993) they correspond to the "real world" descriptor in their framework.

On the other hand, non-realistic media are those designed by people (e.g., drawings, texts, symbols, icons). They require increased effort in processing on the part of the media user. They have been called abstraction media by Heller, Martin et al. (2001), and symbolic media by Purchase (1998).

Semi-realistic media are positioned between realistic and non-realistic media in the continuum. They accommodate a more abbreviated or stylised version of the original information, for example, a diagram, a realistic painting of a landscape, or an edited photograph. They correspond to the representation category described by Heller and Martin (1995), and to the abstraction category as described by Purchase (1998).

Whilst in most cases the distinction between realistic, semi-realistic and non-realistic media is straightforward, in some cases it can present some problems. For instance, examining the case of an animated model: is it semi-realistic or non-realistic? It depends: for example, if the model realistically represents an existing machine, then it is considered a semi-realistic medium. If, on the other hand, it is a model of a phenomenon of physics, such as electricity, then it is a non-realistic medium. It is also worth noting that a realistic medium like a photographic image can be manipulated to become either semi or non-realistic.

Linguistic and non-linguistic media

Linguistic media (e.g., text or speech) represent language-based concepts and facts (Sutcliffe 2003). They are based on existing syntactic-semantic-pragmatic systems of meaning (Bernsen 1996; Bernsen 1997). Non-natural symbolic languages of mathematics, science and engineering (e.g., circuit designs) also belong to this category. Iconographic sign systems, such as hieroglyphs, are also linguistic media. Non-linguistic media includes everything else, for example, images and non-verbal sounds.

There are some differences among linguistic media as they serve different purposes. For example, (written) text is situation-independent, whilst speech is a situated linguistic communication (Bernsen 1996). Teleconference, for example, comes closer to speech than does the telephone, since teleconferencing establishes more of a shared situation than telephones do. E-mail comes closer to text than online messaging (e.g., MSN Messenger) because normal e-mail communication is independent of both parties' place, situation and time (Bernsen 1996). Labels and keywords are well suited for brief expressions of information on menu lines, graph annotations, conceptual diagrams, etc. Braille is a haptic language for blind and vision-impaired people.

Static and dynamic media

Static media persist over time; they offer the user freedom of perceptual inspection, for example, text, or still images. Dynamic media, in contrast, are played continuously and once finished are not inspectable without replay controls (e.g., moving images, sound, and speech).

Dynamic media attract our attention and are difficult to ignore, i.e., they have high detectability, and are highly intrusive to the user (Arens, Hovy et al. 1993). At the same time dynamic media also overwrite working memory, as the user has to process the continuous media stream.

Arens, Hovy et al.'s (1993) criteria for the static/dynamic distinction is based on temporal endurance: static media have permanent temporal endurance, i.e., they do not vary during the lifetime of the presentation. Dynamic media have transient temporal endurance. In this case, if speech and non-speech audio, and animated graphics are considered, they are transient because they cannot necessarily be received when the user wishes (Arens, Hovy et al. 1993). Bernsen (1996) offered a different and more interesting criterion based on freedom of perceptual inspection. If users can decode a representation, in any order desired and for as long as desired, then the representation is considered static. According to this static/dynamic distinction, a representation is also static when it exhibits short-duration repetitive change. Thus, for instance, an acoustic alarm signal that sounds repeatedly until someone switches it off, or a graphic icon that keeps blinking until someone takes action to change its state, are considered static rather than dynamic. The implication is that some acoustic representations are static.

Graphic, audio and haptic

This distinction is based on Bernsen's (1997) criteria for physical media of expression of different sensory modalities: visual (the graphic medium), auditory (the acoustic medium) and tactile (the haptic medium, relating to the sense of touch). To simplify this, this researcher could have considered only audio and graphics as Arens, Hovy et al. (1993) did. However, haptics were added to this category as new developments in this area are increasingly making haptic human-computer interaction a reality (Brewster and Murray-Smith 2001).

Graphics, acoustics and haptics have very different physical properties and are able to provide very different sets of perceptual attributes (Bernsen 1997). These attributes and their cognitive impact can be used in different ways for various purposes. For example, non-auditory media have lower detectability compared to auditory media (Arens, Hovy et al. 1993).

Images in more detail

In light of this media taxonomy, images and animations are examined in more detail.

An image is a non-linguistic, static and graphic medium. It can be realistic, semi or non-realistic. At one extreme, an image allows a realistic (or quasi-realistic) perception of the properties of objects, persons or places, which cannot easily be represented linguistically (Bernsen 1996) as they may be in an unedited photograph. It imitates or records the external form of real objects, processes and events by representing their physical appearance. At the other extreme, non-realistic images are those whose specificity has been highly reduced for a purpose. According to Bernsen (2001) images may represent non-perceivable objects, processes and events, regardless of whether these are too small, big, remote, slow or too fast for the human sensory repertoire, or are hidden beneath an exterior, shrouding them from human perception. Images may also represent objects in a medium different from their ‘normal’ physical medium, e.g. by representing acoustic information graphically. Linguistic annotation is often needed to add focus and explanatory contents to the information images provide.

Levin and colleagues (1987) proposed a functional classification for images – drawn or photographed – based on the effect of an image on content recall. They identified five categories - decoration, representation, organisation, interpretation and transformation - to describe pictures accompanying text. A *decorative* image is an image unrelated to the content, and the purpose of which is to make the page more attractive. In Levin’s *representation* category, images serve to tell exactly the same story as the other media, making the concepts more concrete and thus aiding retention[21]. The main purpose of the *organisational* use of a picture is to make the content more coherent or comprehensible. It relies not only on the use of diagrams and maps, but also on pictures that illustrate procedures (e.g., how to clear a paper jam in a photocopier or how to perform cardiopulmonary resuscitation). The *interpretative* function of a picture is the capacity to re-code concepts as an aid to understating, i.e., by providing an analogy. For example, the flow of water through a system of pipes may be used to explain the mechanics of blood pressure. The category called *transformation* relates to information that is recorded in a memorable form, not unlike an icon, and in a form different from the other media presentations (Heller, Martin et al. 2001).

Hunter, Crimsoned et al. (1987) categorised graphics by their function, which can be to embellish, reinforce, summarise, compare or to elaborate. The *embellish*, *reinforce* and *summarise* functions correspond to Levin’s decorative, representation, and organisation categories respectively. The different functions that Hunter and colleagues have identified are *to compare*, i.e. where the image is used to contrast or compare with a previous image, and *to elaborate*, in which the image not only reinforces the text but also adds new information that does not appear in the text.

Both Levin’s and Hunter’s classifications are based on images used to support text; they did not consider the possibility of images being used on their own. Indeed, Andre, Muller et al. *(1996)* acknowledged that pictures, without the need for text, can perform particular communicative acts. In contrast to text, comprehension of pictures is not necessarily a linear process; it depends on design, the user’s goal and his/her knowledge of the domain.

Animations in more detail

Animation is “the term given to the addition of motion to images, making them move, alter and change in time” (Dix, Finlay et al. 2004, p. 751). For Gonzalez (1996) animation could be defined as a series of varying images presented dynamically according to user actions, in ways that help the

[21] Tufte (1983, p. 37) showed a graphic that, if used, would save 700 words from a news report.

user to perceive a continuous change over time and develop a more appropriate mental model of the task.

Gonzalez (1996) questioned the conventional assumption that animation per se makes interfaces more enjoyable, understandable, and easier to use. The author stated that very little is actually known about the design and effective use of animation in user interfaces.

To some extent, the theoretical basis for using animation is the same as that for using images and other static visuals, because animations can be considered a subset of visual graphics (Weiss, Knowlton et al. 2002). This theoretical relationship has its foundations in cognitive theory. For example, Paivio's (1991) dual coding theory, which argued that text and graphics are encoded in two different cognitive subsystems, suggested that whether the graphics are static or animated is irrelevant. Thus, up to a certain point, theories of using graphics apply to both the animated and static forms.

Nevertheless, in spite of similarities between animated and static visuals, animation has the capability of demonstrating movement and trajectory, which is lacking in static images. This difference in dynamics raises certain aspects of animation that require special attention when it is being employed.

Weiss, Knowlton et al. (2002) identified five functions of animations:

1. cosmetic - could make the interaction attractive, but can distract users from focusing on the tasks. Corresponds to the decorative function in Levin’s classification (Levin, Anglin et al. 1987).

2. attention gaining function - animations can be used to gain attention - special effects for transitions between frames or animated prompts. They can be used to capture the user’s attention and focus it on salient points. However, this perspective is not unanimously accepted: it is difficult to support the notion that animation is an effective tool for keeping a user’s attention once its “novelty” has passed (Large 1996). Thus, the over-use of animation for the purpose of gaining attention may not be beneficial.

3. motivation function - e.g., exploding fireworks used as feedback for correct answers in educational applications.

4. presentation function - the most direct application of animation is to use it as part of the presentation strategy. Animation can provide a concrete reference and a visual context for ideas. Since text illustrated with graphics is retained at a higher degree than text alone (Mayer 1997), and, as discussed above, animations can be considered a special case of images, one can argue that animation may also improve retention of information. Even if retention is not essential, animation can help present information by defining a concept, rule, or step in a procedure. It can also supplement the text by providing examples of, or elaborating on, a concept, procedure or rule (Rieber 1994). The use of animation as a presentation strategy is particularly helpful when presenting highly abstract or dynamic processes.

5. clarification function - this function employs animation to provide a conceptual understanding without providing new information. Animation clarifies relationships through visual means. It corresponds to the representation category in Levin’s classification (Levin, Anglin et al. 1987).

The implication of these five functions for design relates specifically to the objectives of using animation. The effective use of animation is concentrated in the presentation and clarification functions - functions that support the tasks. The cosmetic, attention gaining and motivating functions may be useful in different ways, although usually their effect is temporary and fades over time, as they are based on their novelty, and do not necessarily support the users’ tasks.

4.2.2.3 The user

Is it enough to have a knowledge of each medium, in order to make an adequate selection? Some researchers have argued that it also depends on the user's knowledge and experience of a domain and task (Alty 1993; Arens, Hovy et al. 1993; Johnson and Nemetz 1998; Mehlenbacher, Miller et al. 2000). For example, Marmolin (1991) concluded that if the domain and task are new to the user, a concrete representation that allows exploration would be appropriate; Marmolin (1991) concluded that if the user has a lot of experience in the domain and task, then a more abstract representation may be adequate. One possible explanation was offered by Arens, Hovy et al. (1993): they found that if the user is familiar with the subject matter, he/she will have to process less information to correctly interpret the representation. For example, a diagram of a car engine would help the novice to locate a component, whereas the expert may only need the component name.

Additional factors considered in the literature are user's aptitude, and spatial ability (high, low) (Morrison and Tversky 2001). Arens, Hovy et al. (1993) added other factors: interest (high, low) and opinions (good, neutral, bad) on the topic, language ability (high, low), and emotional state (calm, angry, agitated). Schar and Krueger (2002) added computer experience, and educational level, and Sutcliffe (2007), age groups (younger/older people), cultures, and socio-economic situation.

In order to ensure compatibility with the user's understanding, media should be selected that convey the content in a manner compatible with the user's knowledge and capabilities; for example, the radiation symbol and road sign icons are used to convey hazards and dangers to users who have the appropriate knowledge and cultural background (Sutcliffe 2003).

4.2.2.4 Tasks

Up to this point, information type, media type and user characteristics have been considered to select media. The final variable in the equation of media allocation is the user's tasks.

When selecting media, the crucial question faced by the designer is "What information content does the user need for this task subgoal or input-output interaction?" (Sutcliffe 2003, p. 119). In other words, the main problem is to determine which media best transmit the information needed by the users to carry out their tasks (Table 7) (Johnson and Nemetz 1998). Alty (1993) considered that not only is the task important, it is the "main determining factor in media choice" (p. 5). Ideally, media should represent the task domain at a level congruent with the difficulty of the task (Williams, Duncumb et al. 1996).

Table 7: Task characteristics (Sutcliffe 2003).

Type of task	Tasks
Problem solving	• Analysis • Transformation • Exploration
Language based	• Text search
Logical reasoning	• Proof of theorem
Spatial	• Moving • Positioning • Orienting

Research on the relation between tasks and media is very limited and difficult to generalise. For instance, Morrison, Betrancourt et al. (2000) reported on findings of how three-dimensional and two-dimensional graphics compared to one another: for some tasks (e.g., memory) there was little difference between them while for other tasks (e.g., estimation) 2D graphics were superior.

The importance of understanding tasks in order to use the appropriate media has been recognised by the "media richness" theory developed by Daft and Lengel (1984) for organisational communications. The theory recognises that media have varying capabilities for resolving ambiguity and reducing uncertainty, and that task performance improves when the medium fits the task. Daft and Lengel's media richness theory was developed for human-human communications, but the main principle can also be applied to human-computer interaction and to human-human computer-based communications.

4.2.2.5 Choosing the appropriate media

The "holy grail" of media allocation and combination is a set of rules and guidelines on how to select and, if necessary, combine the appropriate media based on the information type, the user, the task and the characteristics of the media. The literature on this subject ranges from purely intuitive remarks, the consideration of which is deemed unnecessary for the purpose in this section, to theoretically grounded or empirically based findings, which have been considered above. There is no such thing as good or bad media, as they are contingent on several factors of which the information type, the task and the characteristics of the user are crucial (Arens, Hovy et al. 1993; Morrison, Betrancourt et al. 2000; Najjar 2001; Schar and Krueger 2002). For example, auditory media, such as speech, make dialogue more salient. Alty (1991) cited, as an example, that children recall the dialogues better when given a story in audio-only compared to visual and audio. Video and audio in combination may be better-suited to action information – Alty stated that this combination improves the recall of this particular type of information. He also suggested that audio information seems to stimulate the imagination, whilst spatial visualisation is handled better visually, as might be expected. Diagrams are more effective in conveying ideas, whereas text is more appropriate for detail for language-based content (Alty 1991), and still image for physical detail of objects (Sutcliffe 2007). These kinds of recommendation, however, are too generic and do not differentiate between particular contexts, or consider media combinations.

The guidelines can be stated in two different but complementary directions:

- based on information type, and/or task, and/or user characteristics, which medium/media is/are more appropriate and effective (e.g., "x" is well represented by medium "y");
- what sort of information type(s), and/or task, and/or user characteristics is/are best supported by a particular medium or media combination (e.g., medium "y" is adequate for representing "x").

When a selection has to be made from two or more presentation forms for a given item of information, the best choice can also depend on other factors, such as the cost of production or the complexity of the idea being conveyed (Alty 1993).

In what follows, the main findings relative to media choice are reported. They are organised, initially, by information type and, subsequently, by media, tasks and user characteristics[22].

Abstract x concrete information

There is an important difference between abstract or conceptual information and concrete or physical information (Roth and Hefley 1993; Johnson and Nemetz 1998; Najjar 2001; Sutcliffe

[22] It is important to note that the following list of findings contains items that are nonexclusive, i. e., the same data types may (and will) fall into different categories (e.g., a concrete piece of information that is also procedural).

2003; Alty 2004). Abstract concepts, such as “freedom”, “democracy” or “amount”, are more easily and completely represented by linguistic media (e.g., text or speech). In contrast, concrete concepts or physical information, if represented by non-linguistic media (e.g., pictures or moving images), can improve the speed with which information is understood and comprehended. This can involve objects (e.g., a wristwatch), persons (e.g., an actor) or places (e.g., a street), where visual properties, such as shape, colour, texture, or size, are of greater importance (Heller, Martin et al. 2001). Nevertheless, linguistic media can also successfully convey concrete concepts that are easy to visualise without external aids (Morrison and Tversky 2001).

When a partial abstraction of physical information is desired, a non-realistic image may be used, like a sketch or diagram. A good example is the map of the London underground.

Pictures of common objects seem to be recalled and recognised better than their textual names (Najjar 2001), with the exception of conceptually similar items (e.g., they are all animals or tools) – in this case the pictures cause confusion. The learning advantages of pictures, compared to text, may exist because pictures have more features available for processing than words do, and pictures may help to access meanings more quickly and completely than words (Najjar 2001). It appears that more elaborative media (e.g., pictures instead of text, or text instead of audio narration) may improve learning performance more than media that may not be as elaborative. This extra cognitive processing of information, facilitated by elaborative media, helps to better integrate the material with prior knowledge, helping to improve learning. The learning advantage for graphics may occur because graphics contain more features (than words) that are available for the extra processing (Najjar 2001). Also, reading text appears to cause learners to more actively process information than simply hearing verbal narration.

Procedural information

Procedural information can be represented by static or moving images. For this type of information, Sutcliffe (2003) and Hegarty, Quilici et al. (1999) advocated the use of a series of images with text captions. For example, the necessary steps for assembling a desk can be illustrated by images with text captions containing explanations for each step. Another example is the use of images and text for explanations on how to clear a paper jam in a photocopier.

Weiss, Knowlton et al. (2002) supported the use of animations in situations where the procedure involves equipment that is not readily available to the user or equipment that would be particularly costly to use. The authors noted that realism and fidelity should be high ensuring that users have a simulated experience.

The decision between static and dynamic media, in this case, has to do with the complexity of the information. Weiss, Knowlton et al. (2002) stated that the more complex a concept, the more important the clarifying role of animation becomes. On the other hand, the use of animation for simple procedures can have a detrimental effect, i.e., a relatively simple procedure may appear to be more complex when animation is used. This was confirmed by Faber, Meiers et al. (1991). They conducted several experiments to explore under which conditions media combinations that include motion pictures have considerable advantages over media combinations without motion pictures. Using the criteria of efficiency, effectiveness and time required for successful learning, motion picture presentations were found to be superior with regard to learning more complex motion patterns, but this was not the case for other learning tasks involving simpler motion patterns. Heller, Martin et al. (1993) carried out an experiment to test this finding, using different media in an interface to solve a process control problem (text-only, graphics-only, graphics and warnings, and graphics and speech). Participants were tested on their comprehension of different concepts. The results showed that different media had no effect for simpler concepts; the same was true for very complex concepts – they were considered difficult regardless of the media used. For concepts that lie between these two extremes, i.e. reasonably complex concepts, comprehension does seem to be influenced by the medium used.

Visual-spatial information

Visual-spatial information may be presented in a realistic still image, for example, a photograph (Sutcliffe 2003). To facilitate the visual identification of objects, processes, or events, Bernsen (1996) recommended the use of high-specificity still images in as high dimensionality and resolution as is possible to attain. An illustration of this guideline is the use of photographs in criminal investigation. What would make it very difficult to identify a person based on a linguistic description, becomes much easier and more precise using a still image (Bernsen 1996). To convey events of life, such as social or cultural situations, the use of video is recommended as, in this case, realism is important (Bell and Johnson 1993).

Spatial information shows where things reside in relation to one another in space (spatial relationships) or explains how we can get from one place to another (Heller, Martin et al. 2001). Location information and the composition of objects are best depicted by pictures and maps (Levin, Anglin et al. 1987; Andre, Muller et al. 1996; Heller, Martin et al. 2001; Najjar 2001). For example, a map of bus routes in an unfamiliar place is usually more effective than a textual description of the routes. Spatial information that involves complex pathways may be conveyed by a moving image, for example, animating a walk through a building. The superiority of graphics over text for spatial information was also verified in a study on learning (Morrison and Tversky 2001). Andre & Rist (1993) argued that with spatial information, graphics make interpretation of information easier; however, they found that the addition of text makes it more accurate.

Dynamic and static media

Static information types are characterised by states, descriptive attributes, relationships, spatial orientation, and values. Dynamic information types are characterised by procedures, events, causality, and discrete or continuous actions (Schar and Krueger 2000).

If the basic characteristics of the information in the domain of knowledge are dynamic, then dynamic media should be employed (Sutcliffe and Faraday 1994; Schar, Zuberbühler et al. 2000). For instance, dynamic media is useful for demonstrating sequential actions in procedural information content. Dynamic presentations implicitly offer more cues about the dynamic information content, e.g., aspects related to duration and contiguity of the events.

Dynamic media can have a useful illustrative effect; dynamic visual information, in particular, can be used to illustrate structural, functional or procedural relationships among objects and events in a specific domain. For example, dynamic features can explain sequential relationships of procedural actions in electronic troubleshooting (Schar and Krueger 2001; Lewalter 2003). Indeed, in an experiment, animations were superior to both text and text+pictures in supporting procedural problem solving (Schar and Krueger 2001).

Dynamic media, either semi or non-realistic, have been recommended for explicitly representing complex or continuous physical actions and behaviours that are not directly observable, for instance, the blood flow in the human body, the flow of electrons in an electrical system, or chemical changes that result from experiments (Schar and Krueger 2001; Sutcliffe 2003). When the difference between two closely related concepts is not visible to the naked eye, animation has a clarifying function: it can highlight key differences as a cue to help learners recognise the differences. Another use is for simulating causal models of behaviours of complex systems, to show how the manipulation of one variable affects other variables. For example, actual movements of various gauges in an aeroplane cockpit can be displayed through dynamic visual presentations, to describe the causal relationships between the components (Schar and Krueger 2001). Dynamic media can also provide a visual analogy for understanding abstract and symbolic concepts, e.g., velocity and acceleration. These concepts become concrete and directly observable when they are represented by computer-controlled animation. A visual analogy may help users to build up a mental model, thus supporting the thinking process in problem solving (Schar and Krueger 2001).

One aspect that should be carefully examined when including dynamic media is the danger of information overload. If the flow of information is not controllable and the information is complex, it can be difficult for users to integrate it. Several findings have indicated that information should be structured into sequences with natural breaks that reflect the different sequences (Faraday and Sutcliffe 1997; Schar, Zuberbühler et al. 2000), so that information load becomes manageable (Sutcliffe 2003). Messages should be delivered at a pace that is either under the user's control or at a rate that allows for the effective assimilation of information, without causing fatigue. Two ways of avoiding overload of the user's information-processing capacity are to avoid excessive use of concurrent dynamic media, and to give the user time to assimilate complex messages.

Another use of dynamic media is to attract attention to specific tasks or presentation displays. For example, special relational movements among numerous gauges in an aeroplane cockpit can be highlighted, in order to focus the user's attention by only animating the relevant features of the visual display (Najjar 2001). The display of a warning message is also facilitated by dynamic visual media, when combined, specifically, with non-speech audio.

On the other hand, there are situations where there are advantages of using static media. Text, for example, as compared to auditory narration, has been found to be a better aid to information retention over longer periods of time (Najjar 2001). Key facts and important messages are conveyed more effectively by static media (text, still image), because users will frequently only acquire a general idea through dynamic media (Sutcliffe 2003). Furthermore, unlike audio, text allows the user to process the verbal information at their own pace. However, according to Najjar (2001), the use of audio verbal information is preferable, if the information only needs to be remembered for a short period of time and/or if the visual channel is already occupied. Moreover, the employment of static media is due not only to its strengths and advantages over dynamic media, but also to its role as an alternative to dynamic media, for instance, when few resources exist for the development of complex animations or films.

Descriptive and value information

Linguistic media (text, speech) are preferred for information describing the properties of objects, agents, or the domain (Sutcliffe 2003). For example, narrative text describes the properties of a chemical compound such as iron. When describing objects and agents with physical attributes, language may be combined with an image.

Numeric text and tables are appropriate for representing numeric values and quantitative information (Tufte 1997), for example, the height and weight of a person is given as 1.8m, 75kg. Speech is not effective for values because they usually need to be inspected while a task is being performed, so a persistent medium is advised here.

A non-realistic image (e.g., charts, graphs) represents relations within and between sets of values or conceptual relations between objects and agents (Tufte 1997); for example, the values for rainfall in Bath for each month can be displayed using a histogram. Graphs and charts can be combined with captions and tables to summarise trends, differences, and categories in quantitative data.

Events and temporal information

For significant events and warnings, sound or speech help to alert the user. For example, the outbreak of a fire can be conveyed by sounding an alarm followed by a red marker on a diagram of the building showing the fire's location (Sutcliffe 1999). Abstract events may have to be explained in language (Bernsen 1996). Non-speech audio is best used to attract attention (like animation) or provide signals/feedback for events which have occurred in a system (Bell and Johnson 1993).

Temporal information may be illustrated in sequence as lists, text, or graphical images such as Lifelines (Plaisant, Milash et al. 1996; Shneiderman and Plaisant 2009). Temporal specifications and temporal relations between states, events, or actions could be communicated by text. Graphics can also be used for temporal information, but with limited applicability. Overlapping events and certain time specifications (e.g., mostly, periodically, or in the future) are hard to express using only graphics (Andre, Muller et al. 1996).

State and causal information

For states, the still image or linguistic media are preferred (Faraday and Sutcliffe 1997). For example, the state of the weather is shown by a photograph of a sunny day. Abstract states, such as a person's belief, may be explained in linguistic media or described in diagrams. If a sequence of discrete states is required, then an animation or a series of still images presented as a slide show may be used.

Morrison and Tversky (2001) found that causal information that is conceptual is represented more effectively by language. Language is ideal for conveying causal and conditional relationships as these are difficult to depict visually.

The user

In the educational field, there are studies that have been done on different user categories. Although the number of studies is not significant, in a review of eight studies, Najjar (2001) found that multimedia is most effective for people who lack prior knowledge or aptitude in the domain being learned. Learners with high aptitude and knowledge appear to be able to learn from relatively non-elaborate media such as text, but low-aptitude, low-knowledge learners benefit most from the elaborate and explanatory advantages offered by multimedia. High-aptitude, high-knowledge learners may be good learners, regardless of the media used to present the information, but novices lack this advantage. These findings are also supported by experiments done by Mayer and colleagues (Mayer and Sims 1994; Mayer 1997; Mayer and Moreno 1998).

Najjar (1998; 2001) has also reviewed studies on the impact of learner motivation on multimedia effectiveness. He found that intrinsically motivated learners learn more, and that multimedia can be used to improve learners' intrinsic motivation. Multimedia material appears to offer motivational advantages, because of novelty, but these advantages due to novelty fade over time.

Morrison and Tversky (2001) showed that in learning tasks, graphics were superior to text only for participants with low spatial ability and this finding was also supported by Mayer and Moreno (1998). Furthermore, it has also been found that people with low spatial aptitude benefit more from instruction containing motion sequences, compared to instruction containing static graphics alone (Rieber 1994; Najjar 2001; Schar and Krueger 2001).

In their review of 30 experimental studies on the effects of multimedia on learning, Dillon and Gabbard (1998) found that the generally conflicting results in the literature comparing multimedia and non-multimedia learning environments, could be explained by the characteristics of the learner: passive vs. active learners, field dependence vs. independence, and learner level. Sutcliffe (2007) also advocates that the selection of media should ensure compatibility with user's existing knowledge and background.

The Holy Grail is a multimedia system that identifies and models the user, and automatically adapts to the user model. This has been recognised by several researchers, but remains a challenge for the research community (Rowe and Jain 2005).

Tasks

Alty (1993) found that guidelines, such as "spatial information is better presented pictorially", do not always hold true. For instance, he mentioned that in experiments carried out with weather forecasts, audio information can be superior to visual information in certain circumstances, despite the fact that it is a spatial task. Alty concluded that what is important for multimedia design is the nature of the information needed by the users to carry out their tasks, and deciding which medium has characteristics that will best transmit such information, is essential in the design process. The information needs of users depend on their goals and their knowledge requirements.

In his discussion of optimal media usage, Marmolin (1991) claimed that the ability to manipulate the representation of information is beneficial to the different phases of problem solving (Bell and Johnson 1993). It was claimed that concrete representations facilitate exploration of a new problem, whereas textual forms support analysis. In between these extremes, a visual (graphical) representation is preferable, as it supports creative thought in restructuring and transforming a problem (Figure 11).

Problem solving phases:	Analysis	Transformation	Exploration
Optimal representation form:	Textual	Visual	Concrete

Figure 11 Marmolin's view of optimal media for phases of problem solving

For instance, verbal media are more appropriate to language-based and logical reasoning tasks; visual media are more suitable for spatial tasks involving moving, positioning, and orienting objects (Sutcliffe 2003). Rieber (1994) emphasised that media should be incorporated only when its attributes are congruent with the learning task. Dillon and Gabbard (1998) reviewed 30 experimental studies on the effects of multimedia on learning and found that images are best suited for tasks involving substantial searching, or manipulation and comparison of visual detail where overlaying of images is important.

Media combination

How to combine media is a central issue in multimedia design. Although some possible media combinations have already been mentioned, these combinations have concentrated on describing the qualities of single media, often related to the type of information. When combining media one has to ask if the positive effects of the single media will still be present when combining different media. Because of the complex human cognitive processes involved in information processing, there is no simple rule for how to combine media.

Media combination allows similar aspects of the same subject matter to be presented in different media, creating an integrated whole (Sutcliffe 2003). Showing different aspects of the same object, for example, a picture and a design diagram of an airplane for aviation engineering students can help comprehension, by developing richer schema and better memory cues.

With the combination of media, interfaces can be created that present information in a way closer to the real world (Sutcliffe 2003). Depending on the context, this can make users' tasks more natural, especially where features of the information match the users' experiences of the real world[23]. For example, a picture of a rainy day presented together with the sound of rain provides a better evocation of the subject, than the picture or the sound alone. Combining media can also help

[23] This aspect was already mentioned in section 4.2.1.

to accommodate user preferences for information in a particular format. For example, presenting text as well as pictures can accommodate users with a preference for either.

Marmolin (1991) made a very important observation that multimedia is not just built out of simple parts which can be experimented with separately. Their representations attempt to utilise the “whole mind”, and to be successful, different media must be combined and coordinated in a natural way; otherwise there will be a risk of information overload (Alty 1991).

It seems that a successful multimedia approach depends more on the combination of media, rather than on the provision of a rich set of media. Combination of media can be used to exploit properties of the human cognition system, to improve, for instance, comprehension, whereas a rich set of media is merely likely to overload the user.

So, what are the combinations of media that work? Bernsen (2002) admitted that it has been difficult to find a way of systematically generating a subset of good and useful combinations of media, which could be recommended to systems developers. His Modality Theory (Bernsen 1997) has identified an exhaustive developers’ toolbox of more than a hundred media types. The number of possible combinations of these media types is evidently staggering and, so far, not one way has been found to systematically generate a subset of good and useful combinations, which could be recommended to system developers. He suggested that the best approach is to list the combinations which have already been found to be useful in experimental or development practices. For instance, it has been found that dynamic media attracts the user’s attention more than static media. For this reason, if dynamic media need to be integrated with other media, then controls should be provided to allow replays (Sutcliffe 2003).

When physical details, such as the dimensions of a building, need to be communicated precisely, captions can be laid over an image (Sutcliffe 2003). Dynamic media, especially video, have an arousing effect and attract attention (Reeves and Nass 1996); hence, video and animation are useful in improving the attractiveness of presentations. Speech engages attention because we naturally listen to conversation.

Najjar (1995) reviewed eleven studies on the use of multimedia to attract the learner’s attention. It seems that certain media can help direct the learner’s attention to relevant information and improve learning. The studies used pictures, drawings, video and graphical information to focus the learners’ attention. This, however, does not necessarily guarantee that the learners will learn more, especially when irrelevant, unrelated media are used, which may distract them and decrease learning performance.

When speech and text are combined, the same wording should be used, unless the speech is referring to a visual attribute of the text or preceding it as an instruction. Speech and text compete for language processing resources so they should not be used concurrently, apart from in language-learning applications (Sutcliffe 2003).

Because images on their own lack focus, linguistic annotation is often necessary to add focus and explanatory content to the information they provide (Bernsen 1997). In addition, the interpretation of many types of image, such as medical X-ray images, microscope images or many types of sound patterns requires considerable skill. Images have limited value as stand-alone representations and for many interface design purposes, images need linguistic annotation. Yet, due to their lack of specificity, linguistic media have limited powers of expression (Bernsen 1997). Focus and lack of specificity generate the limited expressiveness characteristic of linguistic representations, and for the corresponding reasons linguistic representations are complementary to visual representations.

As already noted, the complementary nature between linguistic and visual representations explains why their combination is eminently suited for many representational purposes. Thus, one basic use of language is to annotate non-linguistic representations, such as a map or a haptic diagram; and one basic use of images is to illustrate text.

This was confirmed by Weiss, Knowlton et al. (2002): the finding that static images are more effective when accompanied by an explanation has implications for animation, as there is a natural relationship between static images and animation. Narration is important in helping learners understand animation. If there is no explanation, or if the explanation is inadequate, the learner might fail to develop the appropriate understanding of the subject matter.

Combinations with text and pictures or speech and pictures result in better performance, than when the same information content is presented only through text, speech or pictures (Najjar 2001). Dual-Coding theory (Paivio 1991) provides a possible explanation for the complementary nature of images and linguistic representations. According to the Dual-Coding theory, human cognition consists of two subsystems that process knowledge simultaneously, one processing the nonverbal objects (i.e. imagery) and one dealing with language (verbal). The two systems have different functions: the verbal subsystem processes and stores linguistic information, whereas the visual subsystem processes and stores images and pictorial information. Whilst the two subsystems can be activated independently, their interrelations and connections allow for the dual coding of information. This occurs, for example, when a person sees a picture of a dog and also processes the word “dog”. Paivio’s Dual-Coding theory supports the idea that people learn better when the learning materials involve related verbal and pictorial information, as compared to verbal or pictorial material alone (Najjar 1996a).

There has already been evidence for the Dual-Coding theory in multimedia learning (Mayer and Sims 1994; Mayer 1997; Mayer and Moreno 1998; Najjar 2001). For instance, Mayer and Sims (1994) reported an advantage for animations and narrations presented simultaneously in problem-solving tasks, over animations and narrations presented sequentially, or animations with text.

Mayer’s research on multimedia learning limited the concept of multimedia to verbal and pictorial channels so that it fits with the Dual-Coding theory. One of his conclusions was that students learn better from words and pictures than from words alone. Furthermore, he stated that the corresponding words and pictures should be presented near each other (e.g., text under an image or, even better, within the image) and also simultaneously rather than successively (e.g., narration coinciding meaningfully with animation). The synchronised presentation may help learners to use dual (verbal + pictorial) coding to increase cognitive interconnections between the two forms of information studied.

The problem with dual-coding theory stems from the fact that it is most often used only to explain the learning of simple, concrete concepts (Najjar 1996a). Furthermore, the idea that memory has two modes of representation – one verbal and one pictorial – is very controversial among researchers. For instance, propositional theorists have suggested that information, be it visual or verbal, is stored in a semantic form in the memory (Rieber 1994).

4.2.2.6 Summary of Media Allocation and Combination

To summarise, multiple factors play a role in the decisions of media allocation and combination:

- Characteristics of the information
- Characteristics of the media
- Characteristics of the user
- Nature of the task

4.2.3 Feature 3: Redundancy

Often considered useful in complex and cognitively burdened tasks, redundancy is a significant phenomenon in multimedia systems (Vetere 1997). It is well known that using both visual and audio channels simultaneously to explain a complex diagram, is more effective than using just one channel; it is also true that people use the redundancy offered by multiple channels to improve their understanding of situations (Alty 2004), as redundancy makes complex information more comprehensible.

For example, traffic lights combine colour (red, yellow, green) with position (top, middle, bottom) to indicate stop, attention, and go. On motorways, to symbolise there is danger ahead, three codes are used (Figure 12): the triangular shape, the red colour and the exclamation mark. By exploiting redundancy, the communication of traffic signs becomes more effective also in modern advanced driver assistance systems (Cao, Mahr et al. 2010). In face-to-face interactions, redundancy is constantly used: what is said is combined with intonation, physical gestures, facial expressions, and body language, to improve the interlocutor's understanding. It is through redundancy that we are able to overcome the ambiguity that could otherwise arise in deixis, involving pointing and speaking and often eye and head movements, such as in the classic example "put that there", in which multiple forms of media are used to overcome the ambiguity of the referents "that" and "there". The redundancy resulting from a simultaneous activation of a number of perceptual systems, reduces the number of alternative situations that could induce such a combination of perceptions (Steuer 1992) and therefore increases the likelihood that the information will be received and understood (Heeter and Gomes 1992), by making it more comprehensible (Vetere and Howard 1999) and less ambiguous. It also appears that the more human beings use redundant (but individually useful) information, the nearer they come to exploiting the "whole" mind (Alty 2004).

Figure 12 Danger ahead: example of redundancy in road signs

For complex and important information, redundancy can be vital. For example, in neurosurgery the surgeon relies on the redundancy of the many brain images presented in different media, and located at different positions around the operating theatre, as well as on the actual view of the brain through the microscope, to keep him/her aware at all times of the location and intended path of the brain operation, and of the parts adjacent to the injured or diseased brain section, that must be avoided at all costs. Another example where redundancy can make a difference is for disabled users where different media can compensate the one that is not assimilated by the user (Alty 2004).

In multimedia systems, redundancy is achieved through the integration and synchronisation of different media. It can produce "real-world"-like conditions, and reduce the overload on working memory (e.g. video and audio, animated graphics and text overlay or sound commentary)(Nemetz and Johnson 1998b). Comprehension is directly affected by redundancy, because there is more chance of the information provided being understood. For instance, if there is confusion and misunderstanding as a result of the misperception of information in one medium, then this can be supplemented by providing the same material via another medium at the same time (or in temporal proximity).

In order to exemplify the use of redundancy, in Figure 13 a document is presented in two ways, as a photographic reproduction, and as a textual transcription. Even though the photograph can be zoomed in on, the transcription is easier to read and to search for. In this example of redundancy, there are two representations of the same information shown in different formats (Nemetz and Johnson 1998b).

Copy

A. C. Barnes, New York , Sept. 20, 1930
Merion, Pa.

Shall be at Savoy Plaza, New York City, September 28th until 30th. Would greatly appreciate permission to visit Barnes Foundation and meet you. Will you kindly let me know here at the Biltmore Hotel.

(Signed) Henri Matisse.

Figure 13 Two representations of the same information

If the multiple sensory input channels a person uses are considered, redundancy is related to naturalness (Nemetz and Johnson 1998b). However, it relates to the information content of stimuli rather than their forms. Redundancy is a special case of overlap between channels (Basil 1994) and it occurs when information in one channel repeats or complements what is said in another channel.

Understanding how to use redundancy effectively is still a challenge for multimedia systems designers. For complex information, redundant different media, if combined in a congruent (harmonic, synchronised) way, are considered more effective than using a single medium (Hoogeveen 1997). However, if combined in a non-congruent way, they become less effective and disruption, ambiguity or confusion occurs. Vetere (1997) stated that presently there is insufficient knowledge to help designers manipulate these redundancies to improve interactions. No methodology or criteria on how to apply redundancy in multimedia systems has yet been developed, let alone a theory of redundancy and its effects on usability.

Some studies have shown the effectiveness of redundancy in multimedia systems. For example, students who listened to a narration explaining how a bicycle pump works, whilst also viewing a corresponding animation, generated twice as many useful solutions to subsequent problem-solving transfer questions, than did students who listened to the same narration without viewing any animation (Mayer and Moreno 1998). Similarly, students who read a text containing captioned redundant illustrations placed near the corresponding words, generated about 65% more useful solutions on a subsequent problem-solving transfer test, than did students who simply read the text.

Najjar (1996a) reviewed 30 studies on the use of redundancy in multimedia systems for learning. From those, 20 studies, one of them a meta-analysis of 55 experiments, indicated that presenting mostly redundant information using simultaneous multimedia can help people to learn information more than presenting the same information using a single medium. The improvement in learning appears to be especially strong when the multimedia includes both verbal and pictorial stimuli. Najjar (1996a) found that nine studies using redundant information using simultaneous multimedia showed no difference to learning, as compared to single medium presentations of the same information. This was especially true when the media employed were both verbal (e.g. text and audio) and the single medium was verbal (e.g. audio). Only one out of the 30 studies found that redundancy actually decreases learning. Moreover, Najjar found that redundant media are more effective for learners with low prior knowledge in the domain being learned and this finding was confirmed in another study (Vetere and Howard 1999).

Reinforcing messages through the use of redundant communication of the same message on different media, can not only help comprehension and learning (Sutcliffe 2007), but can also provide rich memory cues (Nisbett and Ross 1980). However, for this to happen, Hoogeveen (1997) pointed out that the level of congruence, that is the degree to which different information types are used redundantly to express the same ideas, has to be taken into consideration. The basic assumption is that a high level of congruence of information types is far more effective than a low level of congruence in aiding recognition, comprehension and learning (Rieber 1994). This could determine the success or failure of multimedia systems, i.e. if the parallel media are incongruent and contradictory, then the resulting conflict will create integration problems, unless the divergences themselves are conventionalised or standardised (Hess-Luttich 1994; Sutcliffe 2007).

Redundancy plays a major role in multimedia systems. This has been recognised by ISO 14915-3 (ISO14915 1998), which states that "if important information is to be presented, then the same subject matter should be presented in 2 or more media.

4.2.4 Feature 4: Significant Contribution of the Media

One of the main strengths of multimedia systems is the opportunity for providing richer forms of interaction and information access, through the combination of multiple media. To be successful in improving the quality of the interaction and the efficiency of information access, different media must be well combined and co-ordinated, otherwise there is a risk of increased complexity and interference to the user from high cognitive and perceptual-motor loadings, caused by interaction and information overload (Alty 1991). Just adding a new medium will not guarantee an improvement in the users' ability to recognise and understand how to interact with a given system, or grasp the meaning of a particular piece of information. Adding extra media can cause the user to not even notice a relevant piece of information, due to attentional overload or distraction by another, less relevant piece of information presented in a perceptually dominant medium (Bearne, Jones et al. 1994). Hence, additional media should be used only if they make a significant and relevant contribution in the transmission of a message. Otherwise, they can distract and interfere in various ways with the users' ability to perform their tasks.

It is important to observe that this kind of problem also occurs in general everyday communications. Our understanding of multimedia can greatly benefit from theories of communication (Oberlander 1995). Grice's theory of implicature (Levinson 1983), for instance, is concerned with the efficient and effective use of language in conversation. One of its maxims, the maxim of quantity, is related to the fact that, when making a contribution to a conversation, this contribution must carry all and only the necessary information; not more and not less than what is required. Another maxim, the maxim of relevance, states that one should make the contributions relevant.

Examples found in the Scottish Tourist guide, described in section 2.3, clearly introduce animation that has no useful function. It is an unnecessary stimulus that serves only to distract the user's attention away from the relevant pieces of information, as it is perceptually domineering in the display. Instead of causing the performance of information seeking to deteriorate (Zhang 2000), animations could have been usefully used in other ways, such as to demonstrate the routes to some of the destinations or to attract the user's attention to relevant parts of the information, as in an explanatory guide.

The simple addition of a medium and the resulting increase in sensory stimulation does not guarantee an improvement in recognition and understanding; it can easily exceed human attentional capabilities (Bearne, Jones et al. 1994) and interfere with cognitive processes (Heeter and Gomes 1992). For example, in an interesting study, Palmiter and Elkerton (1991) measured the effectiveness and efficiency of animated demonstrations for users learning procedural computer-based tasks. Compared to the use of text only and to the use of a combination of animation and spoken text, the study revealed that the animation groups were faster and more accurate. However, when retested seven days later, the text group was faster and as accurate as the other groups. The authors claimed that the processing of text made users retain more of what was learned. The problem with this experiment was that exactly the same text was spoken for the combination group while they were watching the animations. In this case, the animations kept users from processing the auditory verbal information that was being presented simultaneously, due to capacity limitations. A better approach would have been to recreate the audio, making it more suited to the animations.

In a hypermedia application - a literature multimedia encyclopaedia (Nemetz 1996) – an example of this feature can be found. Figure 14 shows a passage of a book that illustrates a particular style of a writer. This passage is presented in text and, optionally, in audio. The audio is composed of two channels: the first contains the reading of the passage by a narrator, and the second contains an audio-effect that resembles the sound of wind. This effect provides an atmosphere to the narration, associating its contents with the name of the book: Time and Wind. In this case, the audio-effect makes a fundamental contribution, because it actually reinforces this association, enhancing its semantics and making it more pleasant, whilst at the same time not hindering comprehension (Nemetz, Winckler et al. 1997).

Figure 14 A passage from a book (Nemetz 1996)

The theoretical explanation for this phenomenon resides in studies done on perception, or, more specifically, attention. There is evidence that attention has a limited capacity and that it is selective in the area of vision and audition (Pashler 1999). In vision, for instance, limited visual attention means that only a small amount of the visual information available on the retina can be processed and used. Divided attention arises from our limited capacity – at any moment we must divide our mental effort among tasks, each of which requires more or less attention. However, it is difficult to attend to more than one stimulus simultaneously, if at least one of them is highly detectable and intrusive. When this happens, we usually give some stimuli a higher priority, putting others on hold. This is what is called selective attention – we select what we need/want to attend to, and we filter the rest. The problem is that we may be distracted by unattended stimuli. Studies have shown that in general, objects in our peripheral vision can capture our attention (Zhang 2000) and, because attention has limited capacity, the available resource for attention on the pertinent information is reduced, and consequently information processing performance, including time and accuracy, deteriorates (Zhang 2000). This is also valid for auditory information processing.

Aware that animations attract users' attention, numerous companies now advertise on the World Wide Web using banners containing animations. In a study intended to investigate the effects of banner adverts on user search and browsing behaviour, Burke, Gorman et al. (2004) demonstrated that, although people can filter the adverts that show up on pages (selective attention), they are in fact distracted by them, especially animated ones (limited capacity).

Sutcliffe (2007) recognised limitations in our ability to process multimedia. Using the Model Human Processor (Card, Moran et al. 1983) and Interactive Cognitive Subsystems (Barnard and May 1995), he showed that "certain media combinations and media design will not result in effective comprehension, because they compete for the same cognitive resources, thus creating a processing bottleneck" (p. 395).

In learning tasks, Najjar (2001) pointed out that the use of pictures as decoration (Levin, Anglin et al. 1987) should be avoided, as adding illustrations that are not related to the content does not improve learning. Unrelated illustrations may even make it harder for learners to comprehend the text. The same could be said about cosmetic animations (Weiss, Knowlton et al. 2002) that are even more intrusive. The information being presented in one medium needs to support, relate to, or extend the information presented in the other. Several studies have shown that adding closely related, supportive illustrations to textual or auditory verbal information, improves learning performance. For example, pictures can improve the recall of textual words, recall and comprehension of textual passages, recall of auditory passages, and comprehension of auditory passages (Najjar 2001).

In several experiments involving learning using text with and without illustrations, Mayer and Moreno (1998) showed that the mere presence of illustrations does not improve the learning of verbal information. Rieber (1994) agreed, stating that if pictures are not congruent or relevant to the text, they may be distractive and interfere with learning. To improve learning, illustrations have to support the text; this allows learners to build cognitive connections between the verbal and pictorial information (Paivio 1991).

4.2.5 Feature 5: Exploration

One of the main advantages of multimedia systems is the increased level of interactivity[24] they provide (Oren 1990; Johnson and Nemetz 1998). This is partly due to the use of our senses in a fuller and more orchestrated manner, and also to a greater flexibility and freedom to explore information. Ideally, neither the author nor the designer should force how the information should be viewed or processed; the user should be in control, exploring the interface and choosing the best media for the task (Sutcliffe 2007).

A high level of interactivity improves sensory stimulation, facilitating human information processing (Hoogeveen 1997). Alty (1993) added that, for hidden or ill-defined goals (or goals not properly understood), it is better to allow users to exploit the interface and choose the best media for the task. In their usability guidelines for multimedia systems, Bearne, Jones et al. (1994) suggested that users must be given control over the appearance and the disappearance of each piece

[24] Level of interactivity, in this context, is the degree to which a computer system is responsive to the user's (explorative) behaviour (Hoogeveen 1997). A low level of interactivity corresponds to what Heller and Martin (1998) called reactive interaction. Accordingly, a high level of interactivity corresponds to proactive interaction.

of information. The feeling of engagement produced by freedom of exploration is also an important issue to take into consideration when designing a multimedia system.

One possible explanation for this phenomenon is that we are used to exploring our environment in an active way. Gibson (1966; 1979) argued that information is picked up by the individual: we do not hear, we listen; we do not see, we look around. He stressed that perception is an active process of seeking out information about the environment and exploring it, in an active cycle of cognitive activities, that are directly concerned with making sense of experience (Neisser 1976). That searching is guided by our cognitive understanding of the domain and by our knowledge of how to search. It is also guided by the environment in which we are searching. In the case of multimedia systems, the system is the environment and the designer provides the support and guidance for searching and exploring. Based on this argument, Marmolin (1991) sustained that the user should be enabled to explore multimedia information in an active way, and that the user should be in control. The support to the user's explorative behaviour, e.g. control of the interaction and manipulation of objects, is key to facilitating human information processing (Hoogeveen 1997).

Carroll (1990) has provided a good account of why exploration is a desirable property of a system and its interface. Exploration allows the user to discover for themselves, the workings, content, and functional uses of a system. Furthermore, users learn best when they are actively involved, when they are doing things for themselves (Redish 1998). For instance, people trying to learn a skill are eager to act, to do something meaningful. So, it is a priority to provide users with an immediate opportunity to act meaningfully. Carroll (1990) concluded that the user should be active, working on real or realistic tasks, as real tasks are highly motivating. Genuine tasks also aid the transfer to real situations, by bringing the learning situations and transfer situations into closer correspondence.

For Nunnally (1981), people explore an object to gain information and understand it, because of a state of uncertainty, curiosity and/or because the object is novel. Berlyne (1971) distinguished two types of exploration: inspective and diversive. The first type of exploration is aimed at uncertainty reduction: a person is aroused by a specific stimulus or characteristic, and investigates it to reduce uncertainty or satisfy curiosity. In diversive exploration, an individual is under-stimulated and seeks arousal.

The basic mechanisms of exploratory behaviour proposed by Berlyne (1971) are orientation, locomotion and investigation. For example, in order to gain knowledge in a purchase situation a consumer engages in inspective behaviour, using orientation and locomotion (for visual inspection of a product) and using investigation (for tactile and functional inspection, where the consumer will affect manual changes in an object). The functional inspection is characterised by manipulatory behaviour, based on a mental speculation about the object in terms of its usefulness and relation to other objects (Nunnally 1981).

Multimedia can be used to facilitate greater exploration in all these areas; however, the media have to be designed to support exploration. The ability of a system to support the user in exploration has to be designed, and does not just happen (Johnson and Nemetz 1998). The system must "invite" the user to explore it, enable them to make guesses of what things might do and what they might find, provide feedback on each action taken in the process of exploration, and offer an easy way to reverse or undo any action taken. Thus creating a safe and inviting environment for exploration, where the user is confident in his actions (Meij and Carroll 1998).

Multimedia systems can have different degrees of exploration. A low level exploration, e.g. only switching a presentation on or off, does not really support our explorative behaviour and will lead to less involvement than systems with a higher level of interactivity, e.g. influencing the course of events displayed, manipulating of objects, and editing content data. Also, different users and situations call for different interaction techniques. For instance, voice-input can be used in a hands-free environment, and pen input can help designers while sketching.

A question remains: how much exploration should be built into multimedia systems and what should exploration be like? Another question is whether exploration is necessary or appropriate for all users in all types of domains. As the work by Carroll and researchers on minimalism (Carroll 1990; Carroll 1998) has indicated, totally free exploration is not always ideal. In fact, they found that, for learning to be affective, it is essential that it is not an unguided immersion, but a guided exploration. Variables include the complexity of the domain and of the work users want to do. For instance, in minimalism documentation, initially researchers thought that exploratory learning would be most appropriate for novices and simple problem domains, and less appropriate for experts or complex problem domains (Redish 1998). They actually found that the opposite appears to be true. A possible explanation given is that when the problem domain is simple and straightforward, users may have little patience for exploratory learning e.g. how to make a photocopy. Carroll and colleagues (Carroll 1990; Carroll 1998) speculated that exploratory learning may be even more important in complex problem domains than in simple ones[25].

More evidence for the guided exploration feature can be found in the literature. For instance, in reviewing 139 studies on educational multimedia, Burton, Moore et al. (1995) suggested that certain instructional design features appear to enhance the quality of multimedia instruction. Amongst these features are higher levels of interactivity, learner control, and structured rather than totally exploratory learning. Structured exploration, in this case, has the same meaning as guided exploration. Najjar (2001) reviewed studies and meta-studies on the impact of interactivity on education, including reviews of more than 170 studies, and found that interaction was positively associated with learning achievement and retention of knowledge over time. He concluded that interaction may improve learning, because it encourages learners to elaboratively process the learning material.

Interactivity is often defined at the intersection of the concepts of communication and control: “Though interactivity always requires information flowing in both directions, it is our input and its effects that distinguishes it from non-interactivity” (Naimark 1990, p. 455). Steuer (1992) considered interactivity to be an important component of telepresence.

An interactive user interface may allow learners to control, manipulate, and explore the material (Schar, Schluep et al. 2000). Schadé (1993) stated that multimedia improves sensory stimulation, particularly due to the inclusion of interactivity. For example, he estimated that reading stimulates about 1% of the sensory capacity of the eye. TV watching stimulates about 25-30% of the eye. If interaction with visual objects is added, 60% or more of our eye is stimulated. In addition, the interactive elements further stimulate motoric behaviour and the brain, enhancing problem-solving and decision-making abilities.

Finally, in a navigational, hypermedia system, user disorientation should be avoided by the provision of a means of orientation allowing the user to easily be able to answer the following questions (Nielsen 1995): Where am I? Where have I been? Where can I go?

4.2.6 Feature 6: Quality of Information Representation

It has been argued that the quality of the representation of multimedia information (e.g. low resolution photograph vs. high resolution) can affect the way people interact with multimedia systems (Hoogeveen 1997; Johnson and Nemetz 1998). Each medium has its own rules and

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[25] Redish (1998) admitted that it is difficult to precisely define the difference between a simple problem domain and a complex one.

conventions and will make its own special demands and requirements upon technology, to enable that medium to be used optimally. Although literacy is required in every medium, most computer designers are not highly skilled in film or video presentation languages (Alty 1991). People are used to high-quality productions, such as in films, DVDs or television, and could expect to see something of the same standard in a computer display. Steuer (1992) considered quality of information representation one key factor of media vividness[26].

The importance of the quality of information representation has also been stressed after a number of experiments (Nielsen 1990) on reading efficiency, in relation to text representation on paper and on screen. The results of these comparative experiments indicated that subjects read 25-30% slower from computer screens than from paper and that they also have significantly higher error rates. Nielsen (1990) reviewed other studies regarding error frequencies of subjects in two test conditions: proof-reading from screen and proof-reading from paper. During the first ten minutes of the experiment, subjects had about the same error rates for the two conditions (25% vs. 22%), but after they had been proof-reading for 50 minutes, the subjects using computer screens did significantly worse, with an error rate of 39% as compared with 25% for paper. Nielsen concluded that this experiment showed that users become fatigued fairly quickly when reading from computer screens. Of course, the technology of computer screens is continuously improving through increasingly high resolution. However, these differences should still be taken into account when presenting text on a screen for users to read.

Based on findings from the literature, Hoogeveen (1995) concluded that, in general, it can be assumed that quality of information representation is important mostly for tasks that include object recognition and/or reading. Sutcliffe (2003) suggested that the quality of information representation is most important for tasks where mental activity and decision making predominate.

Quality of information representation includes technical aspects, such as clarity of presentation and conformity of reproduction (Heller, Martin et al. 2001). Appropriate concerns might include the clarity of characters on the screen, as well as the technical synchronisation of two media, for example, synchronising the motion of the lips and the speech. Regarding speech, quality could be thought of as listening effort, loudness, pleasantness of tone and intelligibility (Mullin, Smallwood et al. 2001). Factors affecting video and image quality are, among others, frame rate, lighting, image size, packet loss and degree of synchronisation with the audio. Other factors could be: readability of text (font, bold, italics), clear mathematics formulae, image details, image resolution, image size, clear and recognisable icons and quality of motion. In virtual reality environments, it is important not to have delays between actions on virtual world objects and feedback (Sutcliffe 2003), moreover, the behaviour of the objects should conform to the laws of physics.

For many applications the quality of the audio and video is extremely important. However, the acceptable level of quality will vary according to the information being presented, the purpose to which it is to be put, the context and the costs and benefits of providing it at a given level of quality. For example, the quality of audio signal received over a mobile phone is often poor. However, for the purposes of holding a conversation, and given the current costs of producing increased audio quality in mobile phones, it is often acceptable. If, however, someone were trying to listen to (or, worse still, join in with) a musical quartet over a mobile phone then the audio quality would be inadequate for this purpose. Similarly, in using images, we do not always need high resolution, and colour images that update in real-time. However, a neurosurgeon engaged in image-guided surgery would need far higher quality images of the brain than might be required for images of a face in a normal video-conferencing situation, unless of course the video conference

[26] Steuer referred to quality of information representation as sensory depth. He considered it to be one factor of vividness. The other factor is sensory breadth, or the number of sensory dimensions simultaneously presented (more related to naturalness, redundancy and media allocation)

was between a patient and a dermatologist trying to assess whether or not the patient's facial blemish was cause for concern (Costello, Johnston et al. 2003).

Users' perception of quality is also likely to vary with the task. If the users are involved in learning a foreign language then the audio quality may need to be substantially higher for success, than if the task is to present a report at a routine meeting. Video quality is likely to be more important in an intense interview situation, than it might be in other relaxed scenarios. User perception of audio and video quality may be directly linked to the level of quality they assume is necessary for the situation (Mullin, Smallwood et al. 2001). User perception is recognised as an important parameter, even for researchers who were previously concerned only with technical aspects (Rowe and Jain 2005). For example, the concept of Quality of Service, a common metric used to measure engineering parameters related to an application, has slowly been replaced by a broader metric - Quality of Experience - that includes user perception (Rowe and Jain 2005).

Usually, high quality dynamic media are the most expensive to produce. Even for process-oriented information, high quality static pictures can compete with low quality animations in terms of comprehension. Schar, Zuberbühler et al. (2000) highlighted this phenomenon when comparing learning effects of dynamic presentations (animations) and static presentations (pictures), where students had to learn about dynamic processes: heart functions, protein syntheses, malaria cycle, solar eclipse and off-side rules in football. Although animations were preferred by the experimental subjects, the learning performance by them was not significantly different. Their conclusion was that a good quality picture can be as good or even better than a bad quality animation (Schar and Krueger 2001).

The quality of information representation not only affects the user's subjective satisfaction, but also his/her stress levels. Wilson and Sasse (2000) showed that users exposed to videos with different frame rates - 5fps (frames per second) and 25 fps - did not notice any difference in quality. However, measured physiologically, the users in the low frame rate condition were significantly more stressed.

4.3 Standards

The features presented in this chapter reflect some of the main aspects of multimedia systems. There are, of course, standards for multimedia design, e.g. Software ergonomics for multimedia user interfaces (ISO14915 1998). This ISO standard includes, in part 1 - Design principles and framework - a number of general principles, namely: suitability for the task, controllability, self-descriptiveness, conformity with user expectations, error tolerance, suitability for individualisation, and suitability for learning. It also identifies some specific multimedia design principles, such as: suitability for the communication goal, suitability for perception and understanding, suitability for engagement, and suitability for exploration. These principles are not totally out of line with the design features presented in this chapter, though they are too generic to be used by designers. For instance, part 3 of this ISO standard presents general guidelines for media selection and combination. Some of the aspects present in the standard are shown in Table 8, together with the corresponding feature that covers the standard.

Table 8 Correspondence between ISO 14915-3 (Sutcliffe 2003) and Multimedia Features

Standard	Corresponding Design Feature
Supporting user tasks – media should be selected and combined to support users' tasks.	Media Allocation and Combination
Selecting media appropriate for users' characteristics – the characteristics of the user population should be considered when selecting media	Media Allocation and Combination
Using redundancy for critical information – if important information is to be presented, then the same subject matter should be presented in two or more media.	Redundancy
Using static media for important messages – still image and text should be used for important information other than critical warnings.	Media Allocation and Combination
Ensuring compatibility with the users' understanding – media should be selected to convey the content in a manner compatible with the users' existing knowledge.	Media Allocation and Combination
Supporting users' preferences – If appropriate to the task, users should be provided with alternative media from which they can select a preferred medium or suppress certain media.	Exploration, and Media Allocation and Combination
Considering the context of use – selection and combination of media should be appropriate in the context of use.	Media Allocation and Combination
Avoiding conflicting perceptual channels – the same perceptual channel (e.g., hearing or vision) should not be used in concurrently presented dynamic media, if the user needs to extract information from both media.	Significant Contribution of the Media, Media Allocation and Combination, and Redundancy
Avoiding semantic conflicts – presentation of conflicting information in any combination of media should be avoided.	Media Allocation and Combination, and Redundancy
Combining media for different viewpoints – wherever appropriate to the task, different views on the same subject matter should be provided by media combination.	Media Allocation and Combination, and Redundancy
Guarding against degradation – technical constraints should be considered when selecting media delivery to avoid degraded quality or unacceptable response times.	Quality of Information Representation

For example, "Supporting user tasks – media should be selected and combined to support users' tasks." – this is correct but in a very generic way – what sort of media for what sort of tasks? (e.g., when is video be more appropriate?). The work presented here goes a step further in a way to give more direction and guidance to designers.

4.4 Conclusions

The features presented here should be seen as pieces of the multimedia puzzle (Figure 16), in the sense that it is their combined interpretation that potentially produces good multimedia designs. For example, exploration and naturalness are important properties of multimedia systems, but their effectiveness is far superior when they are combined together.

In this chapter, a set of six design features was proposed; they were elaborated upon with a variety of evidence from the relevant literature.

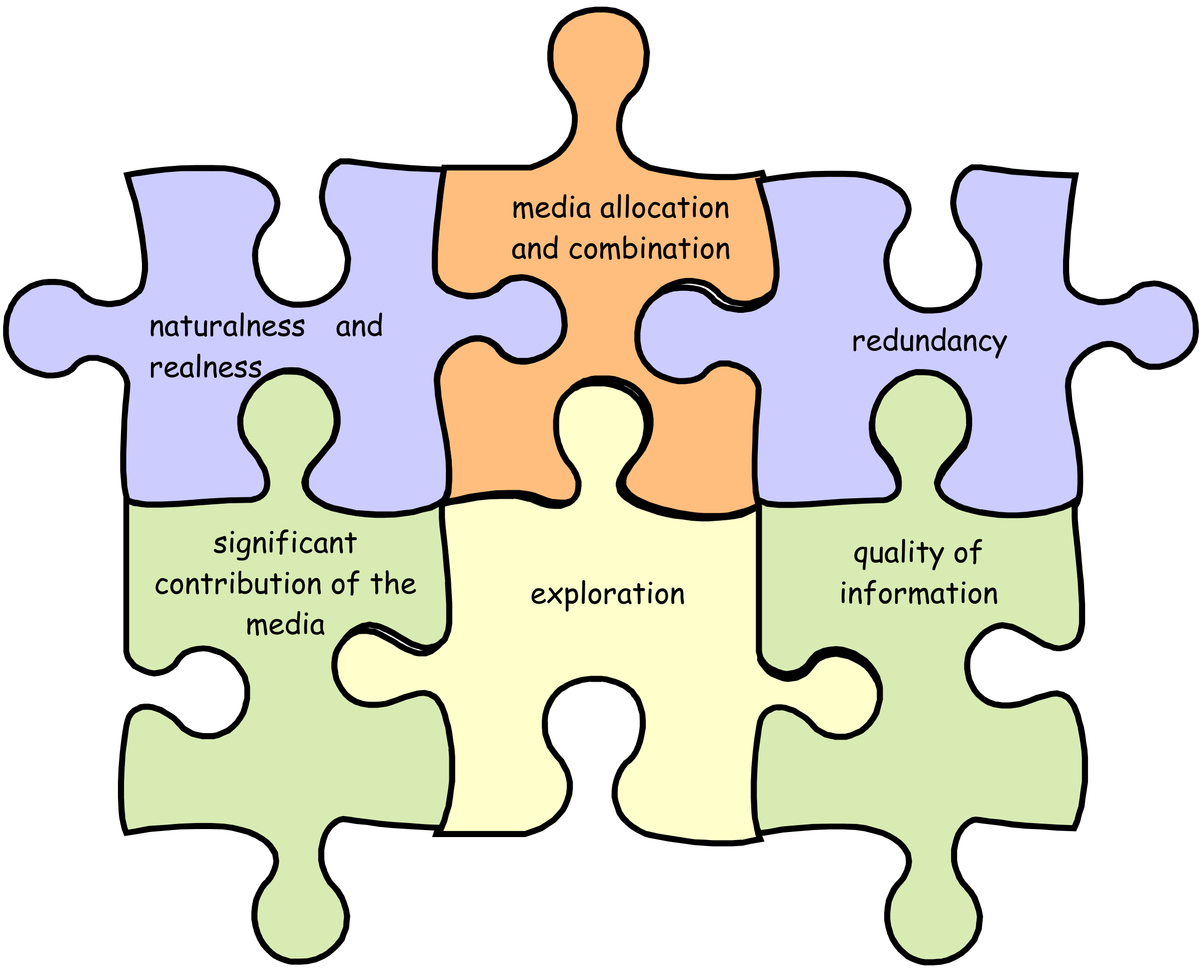

Figure 16 The Multimedia jigsaw puzzle

Multimedia is typical of technological achievements that lack an appropriate HCI theory basis enabling systematic reasoning about the utility and usability of particular design options (Nemetz and Johnson 1998b).

In order to further assess the design features, it is necessary to explore them in different classes of multimedia systems, particular domains and tasks. The next chapter describes the domain chosen for this thesis – electronic shopping. The design features that have been identified will be used in subsequent chapters.

This researcher believes that these design features will provide a consistent basis for interaction designers to make better decisions and, hence, to build multimedia systems that improve the user-experience.

Chapter 5 Electronic Shopping

5.1 Introduction

In order to apply the multimedia design features, a domain had to be chosen to apply them. An area that has grown tremendously in the past 10 years is electronic shopping – an area that has many challenges and interesting open questions for research in HCI, including the use of multimedia technology. These challenges are presented in this chapter.

"Electronic shopping" (e-shopping), also known as "electronic retailing", is a category of e-commerce[27] characterised by commercial transactions occurring between business and consumers via computer networks, which in today's incarnation is most frequently the WWW. Since the product is not physically present and there is no salesperson to give advice or answer questions, from an HCI point of view e-shopping presents a whole new set of challenges, such as, how to design shopping environments (Lohse and Spiller 1998a), how to present product information (Li, Daugherty et al. 2001), and what interactive tools are needed to support consumer decision making (Haubl and Trifts 2000)[28]. The importance and presence of this new way of shopping cannot be underestimated. It has made a big impact and is becoming increasingly more pervasive in society.

It is central to sound HCI research to know the users and their tasks. As a relatively new research domain (Nah and Davis 2002), HCI for e-shopping can benefit enormously from at least 45 years of research in consumer behaviour and consumer psychology. Using this knowledge as a starting point is the sensible path to follow, as several findings from consumer behaviour research have implications for the design of e-shopping applications (Spiekermann and Parachiv 2002).

The main purpose of this chapter is to present an argument for the use of multimedia in e-shopping and why it should be investigated. The emphasis is on the supporting of consumer information search, evaluation of alternatives and choice, using accumulated knowledge from consumer behaviour research, as well as findings that are specific to e-shopping. These findings are presented in this chapter, followed by a summary of the implications that are most relevant to this thesis.

One key aspect that will influence the argumentation in this chapter is the distinction between search and experience product attributes, which is not often considered by HCI researchers in e-commerce. Grounded on the evidence from the research carried out in the consumer behaviour literature, the aim will be to demonstrate the need for people to experience a certain class of products, which in turn is related to the nature of their attributes (search and experience). The main goal of this chapter is to show why the usefulness of multimedia technology in e-shopping needs to be investigated, and to propose one way to carry out such research.

The chapter is structured to follow this line of reasoning:

- First, definitions and research done in HCI on e-shopping before the advent of the WWW are considered, raising possible explanations for their lack of success;
- advantages and problems for users shopping using the WWW are examined;
- we present a model of how people shop, how they make purchase decisions, strategies used during the evaluation of alternatives, the relations between effort and accuracy,

[27] "Electronic commerce" is defined as any form of business transaction in which the parties interact electronically rather than by physical exchange or direct physical contact (Tian and Stewart 2008)

[28] These are the challenges relevant to this thesis, but are by no means the only ones. Other issues like security, payment and delivery are also being investigated by HCI researchers.

and effects of information overload and information format;

- the concept of perceived risk is introduced through a survey. Then the main reasons some people choose not to shop (or shop less) online are presented: mostly the difficulty of judging the quality of products, and the lack of information needed to make a decision.
- in order to show what people do to reduce perceived risk, we use the concepts of “search” and “experience attributes”;
- we will then be ready to compare different strategies consumers employ to learn about products: education vs. experience or, in other words, indirect experience vs. direct experience;
- since the product is not physically present in e-shopping, multimedia experience is presented as a possible way for consumers to interact with experience attributes;
- different products and different ways of experiencing them: a taxonomy of product inspections is introduced;
- the chapter closes with implications for design and for hypotheses.

5.2 HCI and e-shopping before the Internet

Usability studies of pre-Internet online shopping, via videotext, were carried out by Long and colleagues in the 1980s (Gilligan and Long 1984; Buckley and Long 1985; Buckley and Long 1990). They identified several problems with videotext systems, in particular their inability to provide satisfactory product representations for the purposes of evaluation, due to their relatively short text descriptions of products and their lack of graphical capabilities with which to describe a product; relying only on a seven-colour block “mosaic” system. The authors concluded that:

> *“This lack of representational power reduces the likelihood of users developing good internal representations of the objects of their transactions. In the real world people engaged in the transaction of shopping are usually in the physical presence of the object of the transaction and are able to use their full range of senses to develop a rich representation of the object. They are able to know what they will get for the money they expend”(Gilligan and Long 1984, p. 69).*

They went further and pointed out that “In the absence of the object of a transaction we can assert that the poorer the internal representation of the object that a person has the greater the need for the available representation to be as rich as possible” (p. 69). Furthermore, they even foresaw a dead-end for the videotext as a shopping channel (p. 70): “For many transactions it would appear that videotext will prove unsuitable due to its relative lack of representational resolution”[29]. This may explain the low penetration of videotext for teleshopping transactions (Salomon and Koppelman 1992). In the mid-90s, the Internet, via the World Wide Web, provided some of the technologies to meet the requirements identified by Long and colleagues.

5.3 Advantages of e-shopping

As a retail channel, the Internet can be a valuable, interactive medium of communication that facilitates flexible, non-linear searches for up-to-date product information, simulated product/service testing, and it can assist with comparison shopping and decision making. In

[29] The authors claimed that videotext shopping was most suitable for users who knew exactly what they wished to purchase or order.

addition, for intangible products (e.g. music and software), this digital channel can accelerate distribution and provide instant gratification. The Internet can also lower transaction costs by reducing or lowering the number of intermediaries, offering access to a multitude of product/service providers, and eliminating time, location and spatial barriers. In addition to the benefits attributed to other in-home shopping modes (e.g. catalogues), it offers the potential to search and evaluate products from multiple vendors with minimal effort, to place orders and to make payments faster by eliminating the need to call in, mail or fax the order (Vijayasarathy 2002). Bakos (1997) asserted that the Internet lowers the cost of searching to acquire information about seller prices and product offers, and reduces inefficiencies caused by the buyer's search cost. Buckley and Long (1990) identified convenience as the main advantage of home shopping, as it can be done at any time and the goods need not be transported by the shopper. They added that it is especially valuable for consumers that cannot travel easily to shopping areas, for reasons such as disability or lack of transport, and also for people who are bored with shopping or have little or no time available for this activity. Convenience was also the most cited reason for shopping online in several surveys (Jarvenpaa and Todd 1996; Burke 1998; GVU 1998). According to Smith, Bailey et al. (1999), sources of convenience are comprehensive product information and tools to evaluate products. Moreover, Brynjolfsson and Smith (2000) noted that, from the point of view of consumers, good quality product information also serves as a signal of trust[30] and reliability in online markets.

Decision making derived from product evaluation is difficult and consumers make trade-offs during the process, because of the limited human processing capacity and incomplete product information (Bettman, Luce et al. 1998). The Internet provides a degree of interactivity that can potentially improve decision making, by allowing for greater control over product information while reducing information search costs (Alba, Lynch et al. 1997; Ariely 2000; Lynch and Ariely 2000).

Alba, Lynch et al. (1997) pointed out that the benefits of e-shopping are related to consumers' acquisition and processing of information that enables them to locate and select products that satisfy their needs. A related benefit is the reduced information search costs, when compared to traditional shopping, i.e. no need to go to the shops.

5.4 Problems with e-shopping

At the inception of the WWW as a new retail channel, the promises and expectations of online shopping included convenience and easy access to information about products to enhance decision making, while saving time. The problem is that the experience is not always convenient, and the expectations are not always met. Among the reasons are poor interfaces that do not fully support the consumer's tasks (Lohse and Spiller 1998b). Even though the promises are of a quicker and easier shopping experience, sometimes e-shopping can be very frustrating (Hurst 1999).

In contrast to in-store shopping modes, the Internet has a number of shortcomings, including: the absence of face-to-face interactions with salespeople, the inability to touch, smell or feel products prior to purchase (sensory shopping), and the lack of opportunity to socialize. Furthermore, the postponement of consumption enjoyment of tangible products until they can be physically delivered may be unacceptable for some consumers, who prefer instant gratification (Vijayasarathy 2002).

[30] Trust is a complex area in itself (Jarvenpaa, Tractinsky et al. 2000), and one which is beyond the scope of this thesis.

Internet sales figures for different products and services may be a reflection of the channel's strengths and weaknesses. Books, music, travel, computer hardware, software, and flowers are some of the best-selling items on the Internet (Rosen and Howard 2000). The success of these products can be attributed to a match or fit between their characteristics and those of the electronic channel. However, there is much more to e-shopping than books and music. Research should focus on developing technological innovations that can help overcome the current limitations of e-shopping and offer support for a wider variety of product types (Vijayasarathy 2002).

In addition to the inherent current limitations of the Internet as a retail channel, further problems are related to the design of websites. Spiller and Lohse (1998) investigated 137 Internet clothing stores to assess potential problems associated with Internet shopping, and found a significant number of stores with: little product information, low quality pictures, limited product selection, few service features, and poor interfaces. Based on these findings, the researchers concluded that many online shopping problems could be attributed to poor Internet retail site design[31].

Consumer behaviour is a well-researched area in marketing (Wilkie 1994; Engel, Blackwell et al. 1997; Assael 1998; Mowen and Minor 2002; Blackwell, Miniard et al. 2005; Hanna, Wozniak et al. 2009; Solomon 2011). However, comparatively little is known about how web purchase behaviour differs from traditional purchase behaviour, and whether there are any specific web-based factors that should be taken into account. Moreover, there is also a lack of knowledge about how e-shopping applications should be designed to support the consumer's evaluation of products, particularly those that need to be experienced directly (Smith, Johnston et al. 2002). Nevertheless, in order to understand consumer behaviour in online shopping, it is important to understand how people shop in general. This will be covered in the next section.

5.5 How do people shop? Key concepts in consumer decision making

When buying a product the consumer generally moves through a consumer decision-making process (Figure 17). The generic decision-making model used by many researchers (Maes, Guttman et al. 1999; Summers, Gardiner et al. 2008; Hanna, Wozniak et al. 2009) consists of five stages: (1) need/problem recognition, (2) information search, (3) evaluation of alternatives, (4) choice/purchase, and (5) post-purchase behaviour. These five steps represent a general process, which moves the consumer from recognition of a product or service need to the final evaluation of a purchase made. Consumers make decisions in order to reach goals, which include making the best choice among alternatives and reducing the effort in making the decision (Bettman, Luce et al. 1998)[32].

[31] Although this data is from 1998, it will be shown later in this chapter that consumers still face similar problems.

[32] Other consumer goals cited by Bettman, Luce et al. (1998) are: minimising the experience of negative emotion and maximising the ease of justification of the decision.

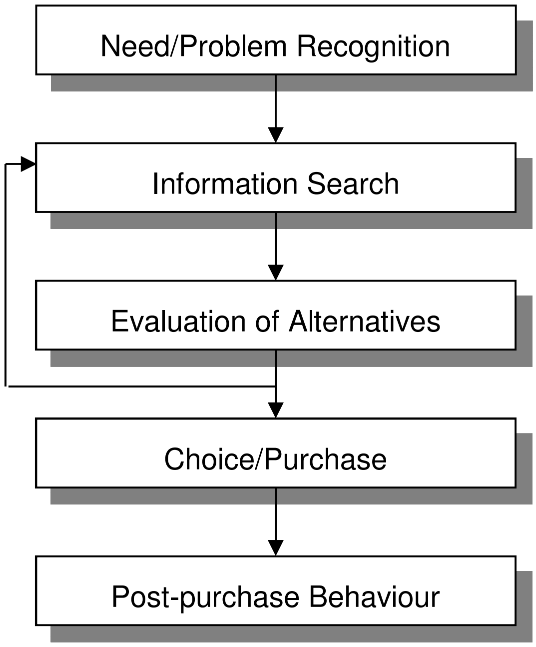

Figure 17 Decision-making process model used by consumers when buying goods or services (after Summers, Gardiner et al. (2008))

Consumer decision processes can be characterised as a form of problem solving (Hanna, Wozniak et al. 2009). When they perceive a discrepancy between an actual state of affairs and a desired or ideal state of affairs, problem recognition arises. Individuals then become involved in a problem-solving process. This process entails a sequence of activities designed to arrive at a decision that will lead to a satisfactory solution to the perceived problem.

Decision making is also considered to be a constructive process (Bettman, Luce et al. 1998); that is, consumers make decisions "on the fly", and the process employed is influenced by the problem's difficulty, the knowledge and characteristics of the consumer, and the characteristics of the situation (Bettman, Luce et al. 1998). A consumer evaluates the effort required to make a particular choice, and then he or she chooses a strategy best suited to the level of effort required. This sequence of events is known as constructive processing: consumers tailor their degree of cognitive effort to the task at hand.

It is important to note that the consumer decision-making model does not assume that decisions will proceed in order through all of the steps of the process. In fact, steps can be revisited and the process can be exited at any time and a purchase may not even be made. For instance, if the consumer knows, or believes to know, all the information about a product, information search is not required (Gilligan and Long 1984). What is important is that shopping is not a single process. The mental or physical activity associated with each stage may vary significantly, based on the financial magnitude and social or psychological importance to the individual of the purchase and product. Deciding to buy a car is completely different from deciding to buy toothpaste; different purchases correspond to different behaviours[33]. Furthermore, even for the same kind of purchase, different consumers employ their own distinct ways of doing business.

[33] According to Kalakota and Whinston (1997), there are 4 types of purchases: *specifically planned* ("I need a 12 Megapixel digital camera with a 10x zoom"), *generally planned* ("I need a camera that is easy to carry around"), *reminder* ("I just realized that I need to buy extra memory for my camera") or *entirely unplanned* ("I noticed this special offer and I'll buy it")

A helpful way to characterise this process was offered by Solomon (2011), where he considered the amount of effort expended each time a decision must be made, presenting it as a continuum which is anchored on one end by habitual decision making and, on the other end, by extensive problem solving. Many decisions fall somewhere in the middle and are characterised by limited problem solving (Figure 18).

Central to the characterisation of purchasing decisions is the concept of involvement. Involvement is related to the subjective personal importance and relevance the consumer places on a purchase, based on interest, needs, or values (Zaichkowsky 1985; 1994).

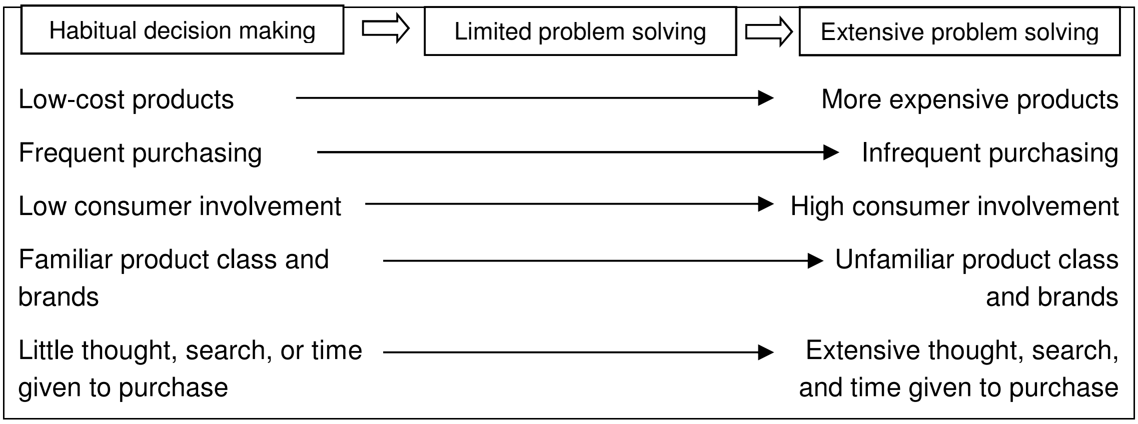

Figure 18 A continuum of buying decision behaviour (Solomon 2011)

Decisions involving extensive problem solving correspond more closely to the decision-making process model perspective. As indicated in Table 9, the extensive problem-solving process is usually initiated by a motive that is fairly high in involvement, and the eventual decision is perceived to carry a fair degree of risk. The consumer tries to collect as much information as possible, both from memory (internal search) and from outside sources (external search). Based on the importance of the decision, each product alternative is carefully evaluated. Evaluation of alternatives will be presented in more detail in the next section.

Table 9 Characteristics of limited versus extensive problem solving (after Solomon, 2002)

	Limited problem solving	Extensive problem solving
Motivation	Low risk and involvement	High risk and involvement
Information search	Little search	Extensive search
	Information processed passively	Information processed actively
	In-store decision likely	Multiple sources consulted prior to store visits
Alternative evaluation	Weakly held beliefs	Strongly held beliefs
	Only most prominent criteria used	Many criteria used
	Alternatives perceived as basically similar	Significant differences perceived among alternatives
Choice/Purchase	Limited shopping time; may prefer self-service	Many outlets shopped if needed
	Choice often influenced by store displays	Communication with store personnel often desirable

5.5.1 Search, evaluation and choice

Based on the consumer decision-making model previously presented in this section (Figure 17), inasmuch as need/problem recognition and post-purchase behaviour are important steps in the decision-making model, for the purposes of this thesis most interest is in the process of evaluation of alternatives. However, in order to fully describe this, the processes of information search and choice/purchase will also be presented, since they precede and follow, respectively, evaluation of alternatives.

Information search: once a need/problem has been recognised, consumers need adequate information to resolve it. Information search is defined as the actions taken to identify and obtain information to make a reasonable decision (Mowen and Minor 2002). Sources of information can be internal, external or a combination. Internal search involves retrieving knowledge from memory for product-related information; external search involves collecting information from outside sources, such as: friends, family members, advertisements, catalogues, consumer reports, sales personnel, packaging, experience with the product(s), and so forth (Hanna, Wozniak et al. 2009). Beatty and Smith (1987) defined external search effort as “the degree of attention, perception, and effort directed towards obtaining environmental data or information related to the specific purchase under consideration” (p. 85).

Evaluation of alternatives and choice/purchase[34]: these activities may be executed simultaneously with the search activity or may emerge only after the consumer identifies and acquires sufficient information on the available alternatives (Solomon 2011). The goal of these steps is to determine a choice set and compare the attributes of alternatives that fall within it, leading to a final decision. The evaluation process itself involves two activities. The first is to narrow down product alternatives to a manageable number, and the second is to evaluate the attributes of each alternative, in order to choose the "best" option:

Identifying alternatives (screening): At this point in the decision process, the consumer has a pool of alternatives that he or she becomes aware of through advertising, peer influences, previous experience or actual visits to stores. How do we decide which criteria are important, and how do we narrow down product alternatives to an acceptable number and eventually choose one instead of others? The answer varies depending on the decision-making process used. A consumer engaged in extended problem solving may carefully evaluate several brands, whereas someone making a habitual decision may not consider any alternatives to their normal brand.

Evaluating attributes: Once alternatives representing possible solutions to the perceived problem have been assembled, evaluation of these options commences in order to arrive at a choice between them. The choice can be effort laden in the case of extensive processing or effortless in the case of habitual processing. In contemplating the various alternatives, consumers may focus on particular product features and ignore others. The product characteristics or features that consumers use to judge the merits of the competing options are known as the evaluative criteria (Hanna, Wozniak et al. 2009).

The **choice or purchase decision** is the outcome of the search and evaluation processes. The degree of ease or difficulty associated with making a choice or actually purchasing a product or service, is a function of the financial, social, and psychological importance placed on the outcome. The decision rules guiding choice can range from very simple and quick strategies to complicated processes requiring much attention and cognitive processing (Mowen and Minor 2002), as is shown in the next section.

5.5.2 Decision rules in the evaluation of alternatives stage

A typical consumer choice involves a set of alternatives, each described by several attributes. The number of alternatives can vary from only one[35], in which case the decision is either to accept or reject the alternative, to many more. The attributes can vary in their potential for consequences, their desirability to the consumer, and the consumer's willingness to trade-off less of one attribute for more of another, and some attributes may be more difficult to trade-off than others. Consumers can be more certain about some attributes and more uncertain about others. Furthermore, the level of information they have can be greater for some attributes than for others. Difficult decisions are the ones involving more options and more attributes, and greater uncertainty about the values of attributes. They also involve decisions in which some attributes are difficult to trade-off.

Researchers in consumer behaviour found that consumers use a number of decision rules to reach a choice among alternative courses of action (Bettman, Luce et al. 1998). These decision rules specify how consumers combine and process information, in order to compare product alternatives. Decision rules can be divided into two broad categories - compensatory and noncompensatory rules (Bettman, Luce et al. 1998; Solomon 2011). Compensatory decision rules involve simultaneously

[34] For the sake of simplification, evaluation of alternatives and choice/purchase steps are analysed together, since the latter is a consequence of the former.

[35] Technically, when there is only one alternative, researchers have called it a preference model and not a choice model (Lowengart and Tractinsky 2001).

evaluating available alternatives on a number of product attributes. Such an evaluation procedure enables a high value positive attribute to make up for other perceived shortcomings. Noncompensatory decision rules, on the other hand, refer to the evaluation of alternatives one at a time, eliminating all those that fail to meet specific attribute requirements. In this evaluation procedure, high value positive attributes cannot offset a poor negative attribute. In the process of decision making, consumers may apply these rules singly or in combination (Bettman, Luce et al. 1998). General descriptions of each rule were developed from several different sources (Bettman, Luce et al. 1998; Blackwell, Miniard et al. 2005; Solomon 2011). The specific rules identified by researchers in this area are as follows.

Compensatory rules**:**

- Simple-additive rule: in the simplest case, consumers merely count the number of positive brand characteristics and select the brand that possesses the greatest number of positive attributes.
- Weighted-additive rule: the consumer takes into account both a product's attribute ratings as well as the importance of its attributes. Consumers multiply attribute ratings by their corresponding importance and sum these for each brand. The alternative with the highest score is chosen. This puts a high demand on consumer's working memory and computational capabilities.
- Majority of confirming dimensions rule: sequence of pairwise comparisons, always selecting the alternative with a majority of winning attributes until all alternatives have been compared.

Noncompensatory rules:

- Lexicographic rule: the alternative with the best value on the most important attribute is selected. If two or more products tie, they are evaluated on the second most important attribute. The process of breaking ties continues until only one product remains. The lexicographic rule seems to be the most common decision strategy that consumers use.
- Satisficing rule: alternatives are considered sequentially. The first option that passes the cutoff levels for all attributes is selected.
- Elimination-by-aspects rule: combination of lexicographic and satisficing strategies. It eliminates options that do not meet a minimum cut off value for the most important attribute. Repeats for the second most important attribute and so on, until only a single option remains.
- Conjunctive rule: the consumer establishes a minimal acceptable quality or standard of performance for each product attribute. Alternatives are compared against each attribute requirement. Any brand that fails to meet the minimum acceptable level is eliminated from further consideration, regardless of whether or not it rates highly on other attributes.
- Disjunctive rule: the consumer establishes more demanding quality standards for each attribute. An alternative has to surpass the minimum cut off for only one of the attributes to be acceptable. For example, a consumer buying a dress shirt sets a 50% minimum for cotton content or a price limit of £40. A shirt remains a viable alternative as long as its fabric contains more than 50% cotton or its price is less than £40.

Consumers also use combinations of strategies. The rule(s) used will depend on time, importance of the decision and involvement of the decision maker (Evans, Moutinho et al. 1996). A typical combination has an initial phase in which some alternatives are eliminated and, especially in high-involvement situations, a second phase where the remaining options are analysed in more detail (Solomon 2011).

5.5.3 Effort and accuracy

Most of the research on consumer information search has assumed that consumers use an implicit cost/benefit (effort-accuracy) analysis to choose a search strategy (Klein and Ford 2002) - what, when, where, and how much to search. Consumers search as long as the marginal gains from the search exceed the marginal costs of the search (Mowen and Minor 2002). Decision makers select strategies in a situation based on some compromise between the desire to make an accurate decision and the desire to minimise cognitive effort. Researchers have found that consumers engage in heavy amounts of external research when in a high-involvement state and doing extensive problem solving (Mowen and Minor 2002; Solomon 2011). The following findings were reported, based on observational studies and laboratory experiments :

- as time availability increases, search effort increases;
- as perceived risk increases, search effort increases;
- as positive attitudes towards shopping increase, search effort increases;
- as education, income, and socio-economic status increase, external search increases;
- as the number of alternatives increases, external search increases, and
- as search costs are reduced, external search increases.

The decision-making process assumes that consumers will gather as much data as is needed to make an informed decision. Consumers form expectations of the value of additional information and continue to search to the extent that the rewards of doing so (what economists call the utility) exceed the costs. In other words, people will strive to collect as much information as possible, as long as the process of gathering it is not too onerous or time consuming (Lynch and Ariely 2000). As Ardissono, Goy et al. (2002) noted, “consumers are ‘cognitive misers’ endeavouring to reduce mental effort when faced with complex decisions” (p. 16).

5.5.4 Information overload

One of the requirements for decision making is that the information presented has to be such that it allows consumers to make decisions and select products that best match their tastes and needs (Assael 1998; Pereira 2000). Since there is an abundance of potentially relevant information and consumers have limited cognitive resources available to process this information, there is a need for designers of online stores to choose wisely what information to present and how to present it (Pereira 2000), so as to prevent information overload. Ariely (2000) pointed out that the interactive nature of e-shopping makes it possible for online stores to provide all potentially relevant information about products, because consumers are selective in their information search.

5.5.5 Information format

The presentation of information has a major impact on consumer choice. Bettman, Luce et al. (1998) found that consumer decision making is affected by making some information easier to process (e.g., sorting or comparing by different criteria). Another finding is that consumers will acquire information in a manner consistent with the form of the presentation (by attribute or by alternative) (Bettman, Luce et al. 1998).

Consumers restructure information if it enables them to facilitate choice. Restructuring is more likely when information is poorly structured and hard to process in its original form (Coupey

1994). Thus, the form in which consumers represent the choice problem is a function of accuracy and effort considerations. Different information formats make some forms of processing easier and requiring less effort, and hence more likely to succeed in their objectives. If processing is difficult in the original format or there are potential accuracy losses, consumers may process in ways that depart from the format.

Ariely (2000) observed that individuals vary in terms of preferences for information presentation and processing. For example, one consumer may prefer to list products by price, while another prefers to view the same information by size. He added that during the information acquisition process, the same consumer may also change his/her needs for information presentation.

5.6 Perceived Risk

Having reviewed the relevant concepts of consumer decision making, the main difficulties people have when shopping online and how these difficulties are related to the concept of perceived risk will now be outlined.

Perceived risk in purchase situations is defined as an assessment consumers make of the consequences of making a purchasing mistake, as well as of the probability of such a mistake occurring (Spiekermann and Parachiv 2002; Gefen, Rao et al. 2003). Dowling and Staelin (1994) defined risk in terms of "the consumer's perceptions of the uncertainty and adverse consequences of buying a product (or service)" (p. 119)[36]. Perceived risk motivates consumers to search for more information, especially in high-involvement purchase situations (Spiekermann and Parachiv 2002) – the main goal of information search is to reduce perceived risk to an acceptable level.

Cases (2002) distinguished three risk dimensions that can be associated with Internet shopping: performance risk, financial risk and time risk. Performance risk (product risk or functional risk) is defined as the uncertainty about a product performing as expected in terms of its functional aspects, and thus delivering the benefits promised. Dowling and Staelin (1994) made a distinction between product category risk and product specific risk. They defined the first type of risk as "the person's perception of the riskiness of buying an average product in the product class" (p. 119), whilst product specific risk reflects the perceived risk of the specific item being considered, with different products in a category associated with varying degrees of perceived risk. Financial risk is not related to the product itself, but to the channel (Internet) and also to the vendor (Tung, Tan et al. 2001), and whether they are perceived as a safe mode of commerce (Kim, Cho et al. 2000). Finally, time risk stands for the possibility that the purchase and/or use of a product might take more time than necessary[37].

Lee, Tan et al. (2000) compared different forms of shopping and confirmed that in-home shopping, such as ordering by telephone or mail, was perceived to be of higher risk than in-store shopping. They cited previous research showing that the most commonly stated reason for not shopping by telephone was "a fear of not getting what was wanted". The reason given was the lack of opportunity to inspect the operation and quality of the products prior to purchase. Because Internet shopping is a form of non-store shopping, it shares some of the problematic features relating to telephone and direct mail shopping. Hence, it is reasonable to expect that consumers will tend to

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[36] Some authors have conceptualised risk not only in terms of negative outcomes, but also in terms of positive ones (risk x benefit) (Gefen, Rao et al. 2003). This thesis follows the conceptualisation based on negative outcomes only, as proposed by Dowling and Staelin (1994) and followed by many others (e.g. (Cases 2002; Spiekermann and Parachiv 2002).

[37] Other researchers (e.g. Solomon (2011) have identified other dimensions to risk: social, psychological, and physical, that do not have a prevalent effect in e-shopping (GVU 1998).

perceive a higher level of risk when purchasing products through the Internet than by in-store means (Spiekermann and Parachiv 2002). Consumers are more likely to shop on-line for products/services that are low in perceived risk, and are more likely to shop in-store for products/services that are high in product risk (Lee, Tan et al. 2000).

Previous studies have found a link between perceived risk and purchase intention. Heidjen, Verhagen et al. (2001) found, through empirical work, that perceived risk of e-shopping strongly influences attitudes towards e-shopping. Studies by Bhatnagar, Misra et al. (2000) and Lowengart and Tractinsky (2001) found that perception of risk significantly decreases the chances that an individual will purchase goods or services online.

The next subsection deals with reasons people have for not shopping more online. If it can be shown that the main reasons are indeed related to perceived risk, then efforts should be made to find means to reduce this.

5.6.1 Reasons for not shopping online and perceived risk

In order to find the main deterrents for e-shopping, this researcher asked 40 people to give reasons why they do not shop more online. The multiple-response question, shown below, is the same used for the (GVU 1998) survey[38].

Why don't you purchase (more) products on the web? (please, check all that apply)

- ☐ Never tried it
- ☐ Too complicated to place order
- ☐ Difficult to judge the quality of a product/service
- ☐ Faster/easier to purchase locally
- ☐ Not familiar with vendor
- ☐ Don't trust that my credit card number will be secure
- ☐ No receipt/documentation
- ☐ Not enough information to make a decision
- ☐ Generally uncomfortable with the idea
- ☐ Heard it’s not a reliable/secure/trustworthy way to make purchases
- ☐ Had a bad experience in the past
- ☐ Don't trust that my personal information will be kept private
- ☐ Don't have a credit card
- ☐ Prefer to deal with people
- ☐ Difficult to find appropriate web sites
- ☐ Site doesn't offer the option to purchase
- ☐ No one home to receive the delivery
- ☐ Other reasons

Table 10 contains a summary of the responses in descending order of frequency, and Figure 19 shows the results graphically.

[38] The decision to use the same question from the GVU survey was so as to compare it for different periods.

Table 10 Reasons for not shopping (more) online

Reason	Count[39]	Percent of Responses	Percent of Cases
Difficult to judge quality	23	16.1	57.5
Not enough info	16	11.2	40.0
Faster/easier locally	15	10.5	37.5
Security	15	10.5	37.5
Prefer people	14	9.8	35.0
Privacy	10	7.0	25.0
Unfamiliar vendor	10	7.0	25.0
Can't find	8	5.6	20.0
Other	8	5.6	20.0
Not home	4	2.8	10.0
Uncomfortable	4	2.8	10.0
Bad press	3	2.1	7.5
No credit	3	2.1	7.5
Not option	3	2.1	7.5
Too complicated	3	2.1	7.5
Bad experience	2	1.4	5.0
Receipt	2	1.4	5.0
Never tried	0	0	0
Total responses	143	100.0	357.5

[39] Count: number of respondents who selected this reason.

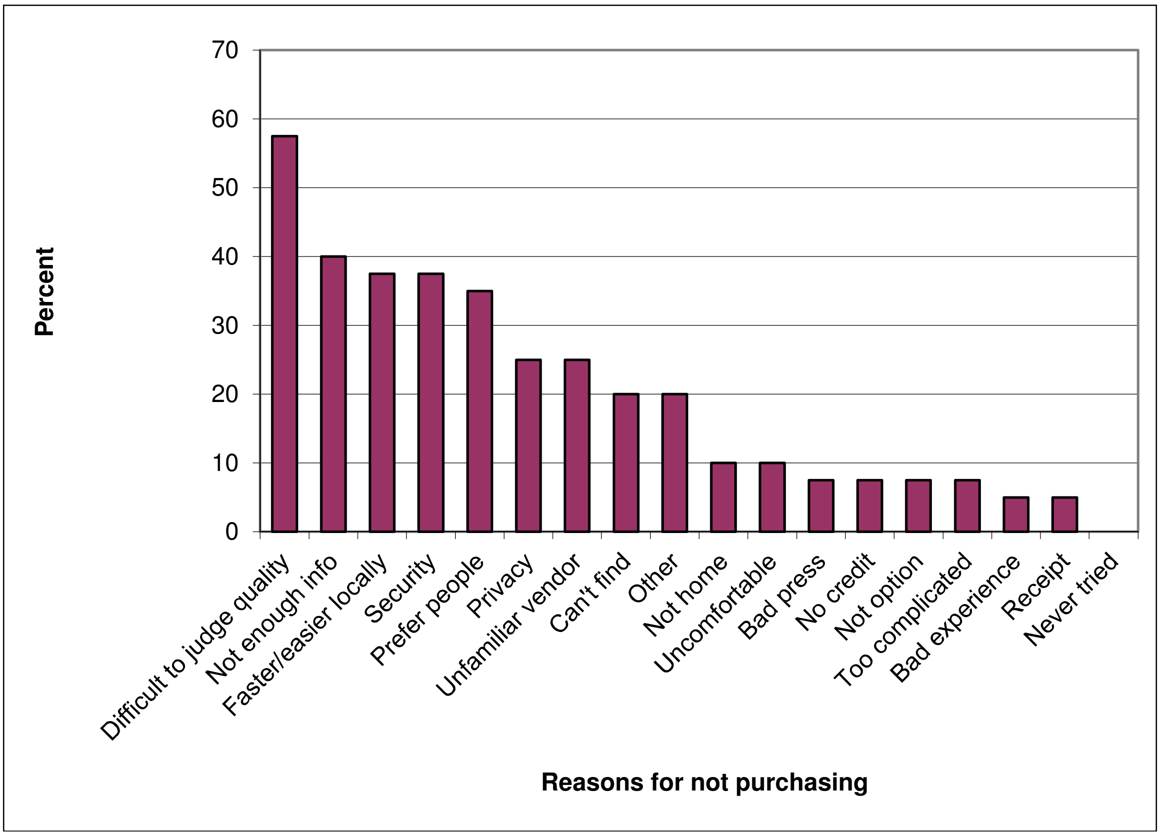

Figure 19 Reasons for not purchasing (more) online, in descending order

Comparing the answers to the same question in the GVU (1998)[40] survey (Figure 20), it can be seen that "difficulty in judging the quality of the product" remains the most cited reason for people not purchasing on the Internet. As a consequence of increased e-commerce penetration and usage, security, which was the second most cited reason in the GVU survey, is now superseded by "not enough information to make a decision[41]".

Using a similar analysis done by Forsythe and Shi (2000; 2003), the following items were used to identify the perceived risks that potentially deter Internet users from purchasing online:

Performance risk:	Difficult to judge quality of a product/service
	Not enough information to make a decision
Financial risk:	Don't trust that my credit card number will be secure
Time risk:	Faster/easier to purchase locally

[40] The Graphics, Visualization, & Usability Center's (GVU) WWW User Surveys were conducted from 1994 to 1998. The data used here is from the last survey, 1998, which involved more than 5000 respondents.

[41] More recent surveys (Cole 2004) have confirmed that concerns about security are indeed declining.

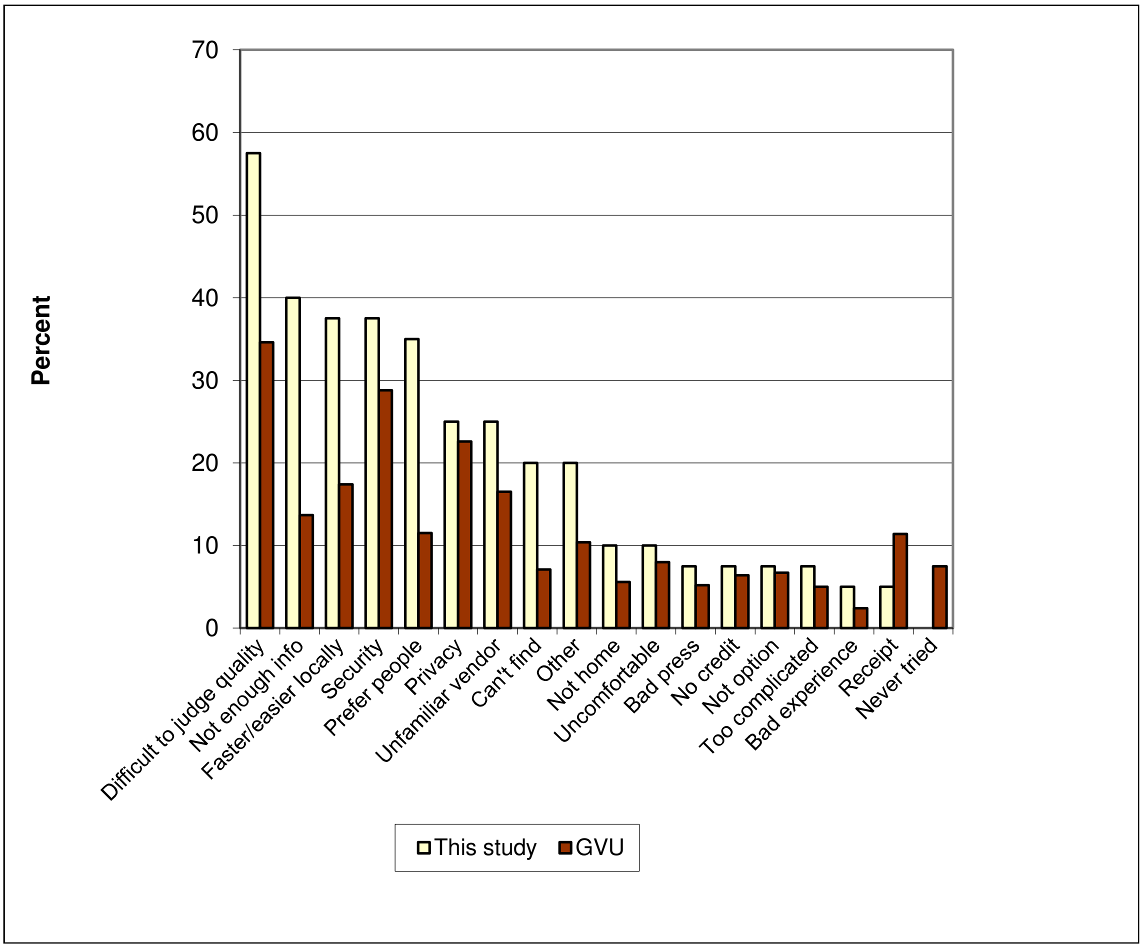

Figure 20 Reasons for not purchasing - contrast with GVU survey

Analysing the responses given to the questionnaire, it can be concluded that perceived performance risk is the major problem consumers have when shopping on the Internet. The difficulty in judging the quality of products has major consequences for the e-consumer. As found by Grazioli and Jarvenpaa (2000), uncertainty increases when the buyer cannot observe the quality of the product or its performance and is therefore dependent on information that is provided by the seller. Many researchers have considered that the Internet is a very poor substitute for traditional shopping, because the buyers' uncertainty through such interaction is of paramount importance as this degrades the experience (Peterson, Balasubramanian et al. 1997). More recent studies (e.g., (Pavlou, Liang et al. 2007; Lee and Lee 2011)) confirm that uncertainty still is the main barrier for online shopping adoption.

The second most cited reason for not shopping online - not having enough information to make a decision - is related both to the quantity and to quality of information. The quantity of information is important because it helps consumers form their consideration sets[42] of alternative products. Quality of information about products refers to accurate and current information and is essential when consumers need to make their final choices. In particular, quality of information is concerned

[42] Consideration set is a reduced set of available products that consumers select in order to simplify the decision-making process. This reduced set includes products/brands/models that the consumer believe offer the best value, and which are substitutable to each other if a purchase decision is to be made immediately (Xu and Kim 2008)

with the usefulness of the available attribute information in aiding a decision maker to evaluate his/her true utility compared with an alternative (Ha 2002).

Time risk, the perception that e-shopping can increase the time to make a decision and that it is faster and/or easier to purchase locally, is also a major deterrent, even if purchasing locally involves associated expenditures, such as driving and/or telephone calls (Bakos 1998). Lohse and Spiller (1998b) found that information search costs are a major determinant of online consumer satisfaction: the easier/faster they make a decision, the more satisfied they are. In addition, Hoque and Lohse (1999) found that subtle changes in the user interface design can considerably affect the information search cost.

Financial (security) risk is also an important factor in the present survey. When the GVU survey was conducted in 1998, financial risk was the 2nd most cited reason for people not shopping online and is now sharing the 3rd place with time risk. Indeed, some researchers have found security concerns to be much less significantly related to the decision to shop online; the Wharton virtual test market study (Bellman, Lohse et al. 1999), which involved a survey of 10,180 people, showed that security concerns did not affect the decision to shop online, and that those concerns were not significant predictors of the decision to do so. In another survey, Swaminathan, Lepkowska-White et al. (1999) interviewed 428 online consumers about their attitudes towards online shopping and found that security and privacy issues played only a minor role in affecting the shopping behaviour of the participants.

The most noteworthy result of the present survey is that perceived risk, in its 3 dimensions (performance, time and financial), appears to be the main factor in explaining why people do not shop more online. This is confirmed by an analysis of 44 items of the GVU survey done by Vellido, Lisboa et al. (2000) concluding that risk perception is the main differentiator between those who purchased products online and those who did not. Another study that analysed the GVU data (Bhatnagar, Misra et al. 2000) confirmed this finding. A further interesting finding of the present survey, when compared both with the GVU survey and also with a study by Bellman, Lohse et al. (1999), is that, among the dimensions of perceived risk, product performance risk has increased in relative importance, whereas financial risk has decreased. More recent studies (e.g., (Pavlou, Liang et al. 2007)) stress that lack of product diagnosticity is key to reduce product quality uncertainty. More recently, Lee and Lee (2011) confirm that this is still a challenge for companies: “in e-commerce online retailers have always been concerned about how to reduce consumers’ perceived uncertainty of product quality” (p. 2). They also state that “quality-uncertainty still exists and it prevents consumers from purchasing products whose information about the quality is difficultly obtained in an online-shopping environment” (Lee and Lee 2011, p. 4)

The rest of this chapter focuses on ways to reduce the most critical dimension of risk: performance risk.

5.7 Search and Experience Attributes

In trying to reduce perceived performance risk (Weathers, Sharma et al. 2007), one of the strategies employed by consumers is to learn more about the products they are interested in. People use different approaches to learning, depending on the type of product, which ultimately depends on the type of attributes it possesses.

There are several different ways to distinguish the various types of attributes of a product. One of the best known is Nelson’s (1981) distinction between search and experience attributes. Search attributes are those that can be fully assessed prior to use, e.g. price of a car, colour of a chair, number of calories per serving of yoghurt. On the other hand, experience attributes can only be assessed by using/trying out the product, e.g. exact taste of a chocolate bar, user-friendliness of a

DVD-recorder. Products have a mix of search and experience attributes[43]; nevertheless it is possible to classify them into search products, if their dominant attributes are search attributes, and into experience products if their dominant attributes are experience attributes (Klein 1998).

The distinction between search and experience products is directly related to the concept of perceived risk. Because consumers do not have complete information about experience products, uncertainty is increased and consequently risk will be perceived as being higher (Lowengart and Tractinsky 2001; Girard, Silverblatt et al. 2002). On the other hand, little uncertainty is involved with search products as consumers can easily assess the quality of the attributes. Lowengart and Tractinsky (2001) pointed out that this explains why search products, such as books and videos, were the first to be sold successfully online[44]. This finding is in line with the accepted view of the effect of risk (Gefen, Rao et al. 2003): the lower the perceived risk the higher is the likelihood of a transaction.

Some studies on perceived risk in e-shopping have demonstrated that consumers do perceive search and experience goods as having different levels of risk. Lowengart and Tractinsky (2001), for example, found that, in decisions regarding the purchase of experience goods, quality uncertainty was significantly more pronounced, than in decisions regarding the purchase of search goods. They stated that, due to the characteristics of experience products, consumers are more likely to focus attention on the information about such products.

Jarvenpaa, Tractinsky et al. (2000) tested a model of consumer attitudes towards specific Web-based stores. They found that perceptions of the store's reputation and size affected consumer trust in the store, more significantly, when the product was expensive and of the experience-quality type, than when the product under consideration was a relatively inexpensive search-quality good. The level of trust, in turn, was positively related to the attitude toward the store and inversely related to the perception of the risks involved in buying from that store. Finally, the researchers found that attitude and the perception of risk affected the consumer's intention to buy from the store.

5.7.1 Ways to reduce perceived risk

Consumers seek to reduce the risk dimensions perceived in a product before they make a purchase decision (Dowling and Staelin 1994). Because uncertainty has been conceived as the difference between the information available (for the task of making the decision) and the information required (to make the decision) (Galbraith 1973), information search is one of the most prevalent risk reduction strategies people engage in before they buy a product (Dowling and Staelin 1994; Spiekermann and Parachiv 2002).

Other risk-relievers identified in the consumer behaviour literature for traditional shopping (Cases 2002; Arnould, Price et al. 2003) are: endorsements, brand loyalty, major brand image, product trial, store image, money-back guarantee, government testing, purchase of expensive model, word

[43] Researchers also identified a third category of attributes - credence attributes - which the average consumer can never fully evaluate even after purchase and consumption (e.g., vitamins, medical services) (Smith and Bush 2000; Lowengart and Tractinsky 2001; Girard, Silverblatt et al. 2002). Credence attributes are not relevant to this research, because the verification of their claims would be too costly or would require a long time to evaluate after purchase (Wright and Lynch 1995) and, also, because they are not unique to e-shopping.

[44] Consumers may find it difficult to assess the quality of a book’s content or the quality of the film in a DVD, but there is little or no uncertainty related to the physical aspects of a book (e.g., size, cover, readability) or of a DVD (it will work in a standard DVD player) (Lowengart and Tractinsky 2001). Peck and Childers (2003) claimed that this happens because consumers perceive these product categories as not differing on material properties, i.e., their haptic attributes are not diagnostic among choices.

of mouth, advice of salesperson, purchase of a cheaper brand, special offers, information on the package and consumer magazines. Specifically, in the electronic shopping context, Cases (2002) identified specific risk-relievers for perceived performance risk, among them the availability of information about products, the ability to compare products and the possibility of seeing the product. These are not entirely new risk-relievers, and have been adapted to the newer mode of e-shopping.

In a study of home shopping, Sundaran and Taylor (1998) found that perceived risk increases not only search effort but also the perceived benefits of search. As Spiekermann and Parachiv (2002) observed, "The more perceived risk reduction potential there is to a product, the higher are the perceived benefits of search and thus the resulting search effort".

It is concluded that being able to evaluate experience products online is key to consumer satisfaction. The challenge is: how can consumers assess experience attributes to make well-informed decisions without even touching the product? The proposition of this thesis is that multimedia technology can potentially be used to enable consumers to "experience" products online. To help understand the role of multimedia as a risk reliever in consumer decision making, the next section shows how consumers learn about products.

5.8 Learning about products: education vs. experience

The findings from the literature on consumer behaviour have shown that consumers learn about products through indirect experience (education), such as advertising, and through direct experience (or simply experience)**,** such as product trial (Smith and Swinyard 1983; Hoch and Deighton 1989). Learning through indirect experience involves obtaining information from companies in the form of advertising, sales people, and the consumer's own directed effort to seek data. In contrast, learning through direct experience[45] involves the process of gaining knowledge through actual contact with products.

5.8.1 Learning from experience

An experience has been described as an "apprehension of an object, thought or emotion through the senses or mind" (Pickett 2000), as "personal and direct impressions as contrasted with description or fancies; personal acquaintance" (Random 1996) and "the fact or state of having been affected by, or gained knowledge through, direct observation or participation" (Merriam-Webster 2003). Hoch (2002) defined experience "as the act of living through and observation of events and also refers to training and subsequent knowledge and skill acquired" (p. 448).

Direct experience occurs from an unmediated interaction between the consumer and a product, through a person's full sensory capacity - visual, auditory, taste-smell, haptic, and orienting (Gibson 1979; Li, Daugherty et al. 2001). Hoch and Deighton (1989) added that, in a direct experience, "the consumer acts on the stimulus, and the actions of the consumer affect the content of the experience" (p. 2). In contrast, indirect experience "stems from symbolic representations of the world experienced through communications with others and mediated representations of the world presented in books, magazines, and on television" (Edwards and Gangadharbatla 2001).

5.8.2 The superiority of direct experience

Hoch (2002) stated that learning from "experience is more engaging than education because it is more vivid and intentional" (p. 449). Hoch (2002) argued that, compared to education, experience is more dramatic and intense, and, because it acts on more than one of the senses, it is more

[45] In this thesis, when used alone, the term experience is a synonym for direct experience.

memorable due to multiple traces in the memory. Learning from experience is driven by the self-identified goals of the consumer, and therefore more likely to be relevant and involving to the consumer (Hoch and Deighton 1989). From his research in minimalist design for learning, Carroll (1990), explaining in greater detail how this happens, noted that "working toward the achievement of a personal goal increases the chance that the activity will be personally rewarding, and hence that the person will remember it and want to do more" (p.74). An activity that is identified by the learner as relevant for achieving his/her goals is:

> *"a powerful source of motivation that can enhance learning. This is achieved when the learning task is the learner's task, when the learning situation is under the learner's control, when the activities are personalised by that learner. In such a situation, each goal evoked and each new episode of interaction come from and belong to the learner and are to that extent already meaningful even if in detail they are unfamiliar" (Carroll 1990, p. 78).*

Furthermore, experience is more impartial, more credible, and not related to the self-interested motives of sources that seek to persuade (e.g. reviewers) (Hoch and Deighton 1989). Consumers are sceptical of advertising claims, especially those that can only be verified through experience. Information learned from experience generally does not produce the disbelief that goes together with information collected from second- or third-party sources. As Hoch (2002) observed, "unlike learning from education, where the source can self-servingly manipulate both the content and manner in which information is presented, experience is more likely to be viewed as agnostic. Product experience is credible because it is basic, with no obvious staging by a self-interested outside party" (p. 450). In a series of experiments, Smith and Swinyard (1983) showed that the perceived credibility of advertising is usually lower than that of direct experience.

Consumers learn about a product prior to purchase to try to predict how well it will provide an expected performance (Daugherty, Li et al. 2005). Li, Daugherty et al., (2002) claimed that consumption experience, i.e. the experience that the product affords (Pine II and Gilmore 2011) is the true value of a product for consumers and that this is the reason they often need to assess the probability that a product can provide an expected experience (Li, Daugherty et al. 2001). Direct experience enables consumers to anticipate the future consumption experience of a product better than indirect experience (Li, Daugherty et al. 2001).

Direct experience is thought to give consumers greater confidence in their product choices (Hoch and Deighton 1989). Fazio and Zanna (1981) suggested that direct product experience is the optimal information source, primarily because it is multisensory, customised to our information needs, and more credible than other indirect sources. As a popular proverb puts it, "experience is the best teacher".

For Li and colleagues (Li, Daugherty et al. 2001; Li, Daugherty et al. 2003), direct experience is superior to indirect because: (1) evidence is self-generated and the most trustworthy for a consumer; (2) a consumer may manage the way a product is experienced by controlling the focus and pace of an inspection to maximise informational input; (3) direct experience promotes better memory, because the information is more vivid and concrete. Moreover, Smith and Swinyard (1983) proposed this chain of logic: direct experience, when compared to indirect experience, (1) leads to more strongly held beliefs, which (2) lead to more strongly held attitudes, which (3) culminate in higher consistency of attitude-behaviour. For Mowen and Minor (2002, p. 63), "learning from experience is more effective, because the consumer is involved in the learning experience and because the information obtained is more vivid, concrete, and salient".

5.8.3 Is direct experience always superior? Linking the type of experience to the product type

Through a series of experiments comparing direct with indirect experience, Wright and Lynch (1995) found that researchers who concluded that direct experience is always superior to indirect experience, did not take into account the differences between search and experience attributes. Contrary to previous findings, they found that direct experience is most important for products that have a predominance of experience attributes, while indirect experience is superior for search products. They argued that, as a result, direct experience is superior for experience attributes only, and indirect experience is superior for search attributes. They hypothesised that the findings from studies showing the superiority of direct experience might be due to the use of products dominated by experience attributes. In their study, Wright and Lynch (1995) used products with an approximately equal balance of important search and experience attributes (e.g., chair-bed, stationary bike).

With search attributes, consumers believe that before product use they have a subjectively reliable inferential rule that links an observable aspect of the product with a desired attribute, benefit, or outcome (Wright and Lynch 1995). With experience attributes, though, consumers perceive a far less reliable link between the information available before use and the benefits or outcomes experienced later. Claims about experience attributes cannot be verified before use, because they are a matter of individual sensory perception – in this case, product trial produces more reliable inferences than does exposure to indirect sources (e.g., advertising) (Wright and Lynch 1995).

The implications of these findings for e-shopping are that both direct and indirect experiences should be designed to enable the consumer to learn about experience and search attributes, respectively. However, since the product is not physically present, how can this be achieved in e-shopping? This will be discussed in the next section.

5.9 Learning about products in e-shopping: multimedia product experience

One of the limitations of e-shopping is that it is not possible to experience the product directly, which, according to Wright and Lynch (1995), decreases consumer learning of experience attributes, limiting the ability of consumers to judge product quality. Does this mean that we have to live with this shortcoming of e-shopping? Is there another way to present experience attributes, even if the physical product is not present?

This researcher believes that multimedia technology can be used to provide a simulation of the product where the consumer interacts directly with a representation of the product. This type of experience, referred to here as "multimedia product experience" (abbreviated as "multimedia experience"), can be classified as a third way of consumer learning, residing between indirect and direct experiences (Figure 21).

Figure 21 Consumer learning

It is important to make a distinction between multimedia and virtual experiences. Li, Daugherty et al. (2001) conceptualised virtual experience as being "psychological and emotional states that consumers undergo while interacting with products in a 3D environment" (p. 14) and Li, Daugherty et al. (2003), as being "interactive advertising in the form of 3D product visualization" (p. 395). The 3D environment referred to in the conceptualisation of virtual experience is actually a 3D visualisation environment, and the interaction only occurs in the visualisation process (e.g., zoom in, zoom out, rotation).

This means that virtual experience is concerned mostly with the use of 3D technology for visual inspection of products, whereas multimedia experience has a wider definition, focusing on human-computer interaction rather than on purely visual aspects. In this way, 3D visualisations, as well as interactions with animations and virtual reality are all examples or special cases of multimedia experience. This broad definition of the concept of multimedia, as encompassing more than just 3D visualisations, is supported by Jiang and Benbasat (2004). Even though the authors did not conceptualise multimedia experience, the results from their experiments show that functional control (a concept embedded in the definition of multimedia experience) is more general than 3D visualisations, i.e., if functional control is provided, there is no need for extra visual control. Conversely, the benefits of functional control cannot be achieved by 3D visualisations alone.

The main goal of multimedia experience for consumers, is to assess product performance prior to purchase (Klein 1998); consequently it has the potential to reduce the uncertainty of product quality, which can prevent adverse product selection. By providing a feel for the product and enabling product evaluation, multimedia product experience ideally overcomes the difficulty created by the lack of physical inspection of products, which hinders the judgement of product quality. Consequently, it reduces perceived risk.

Multimedia experience shares some characteristics with both indirect and direct experiences (Edwards and Gangadharbatla 2001). Both multimedia and indirect experiences are mediated, as the product is not present. At the same time, the interactive nature is shared by both multimedia and direct experiences. Hence, multimedia experience may be able to enjoy the advantages of both direct and indirect experiences (Li, Daugherty et al. 2001).

Multimedia has a great potential for consumers, because it can offer a simulation of the physical product, where the consumer controls the interaction (Li, Daugherty et al. 2001; Schlosser and Kanfer 2001). Indeed, as Li, Daugherty et al. (2001) stated product representations designed to simulate consumption encourage the evaluation of product attributes, because a fuller product representation tends to stimulate a sense of presence from a combination of interactivity, vividness, and mental imagery. Therefore, multimedia experience can improve consumer interaction, enabling consumers to better diagnose the product quality.

According to Li, Daugherty et al. (2001), in conventional stores consumers use a set of relatively uniform inspection procedures. This expected interaction between consumers and products is called "affordances" (Gibson 1979). There are various affordances common to product inspection in stores, that come from the ability of the senses and motor systems to interact with products (Daugherty, Li et al. 2005). In consumer psychology, product affordances are a natural and intuitive set of heuristics that guide consumers interacting with products during prior-purchase inspection (Li, Daugherty et al. 2003). The affordances of any product represent the perceptual cues that influence how consumers expect to interact during direct experience. When we assess our immediate environment, we are aware of some of the affordances each object offers (Gibson 1979). For instance, chairs are to sit on, doors to open and close, and lights to illuminate. An affordance is not a property of an object as much as it is a relationship between an object and the organism that is acting on the object.

In a protocol analysis experiment with 30 students interacting with 3D models of products, Li, Daugherty et al. (2001) found that consumers are active learners - they attend to and evaluate product attributes, and assimilate a product and/or its attributes information into their existing knowledge. They found that this behaviour resembles much of that in direct experience. In the experiment, Li, Daugherty et al. (2001) presented 3 products (a wristwatch, bedding material and a laptop computer) to each subject (30 in total) and asked them to evaluate the products using a think-aloud protocol. Subjects were divided in 2 groups: 2-D and 3D visualisations. The results of the experiment, for each of the products used were:

1. Wristwatch: when visual inspection is the most relevant consumption experience, cognitive evaluation activities are greater in 3D visualisation than in 2-D graphics. In the 3D condition, participants made significantly more product evaluation statements, mainly regarding attribute attention and attribute evaluation.
2. Bedding material: when tactile inspection is the most relevant consumption experience, the number of cognitive evaluations is greater in the 3D condition. Participants made significantly more cognitive product evaluation statements in the 3D condition (only for attribute evaluations and attribute questioning), however, the statements were predominantly negative, which, for the authors, appeared to reinforce the belief that perceived affordances[46] for certain types of products limits the effectiveness of a virtual product experience over traditional forms of indirect experience.
3. Laptop computer: when behavioural inspection is the most relevant consumption experience, there is more cognitive evaluation activity in the 3D condition, mainly for attribute attention and attribute evaluation activities.

They concluded that, to a certain degree, it is possible to provide the main affordances of a physical product through a virtual experience. The main conclusions of this study were:

1. Virtual experience consists of vivid, involving, active, and affective psychological states occurring in an individual interacting with three-dimensional computer simulations.
2. Virtual experience is closer to direct experience than to indirect experience in terms of effective consumer learning.
3. Virtual experience is even advantageous over direct experience when, for instance, animated product attributes capture the consumers' involuntary attention and frame a different perception of the product than one purely based on direct experience.
4. What separates virtual experiences from indirect experiences, but causes them to resemble direct experiences, are the virtual affordances a 3D object or environment provides. Virtual affordances are the means by which consumers can interact with a product in a 3D visualisation in much the same way as in a direct experience.

What Li, Daugherty et al. (2001) did not test was if virtual experiences could benefit consumers in making better decisions, while comparing and choosing products. Their shopping environment was populated by only one product for each product class (e.g., only one wristwatch), and the only tool available to inspect the product was a 3D visualisation tool. This kind of situation in which consumers experience a product without a base for comparisons is potentially very detrimental for their decision making (Muthukrishnan 1995; Hoch 2002). The lack of information about search attributes and the absence of alternatives for comparisons are exactly what marketers use in order to seduce and persuade consumers, and form the basis of advertisements; this is seller-centred and not consumer-centred design. Figure 22 shows an example of a virtual experience (3D

[46] Heeter (2000) made a distinction between real and perceived affordances: "in the design of experiences, real affordances are not nearly so important as perceived ones; it is perceived affordances that tell the user what actions can be performed on an object and, to some extent, how to do them."

visualisation) of a car, where the basic visualisation tools are available: rotate (left, right, up, down), zoom in and zoom out; probably not enough information to make a purchase decision.

Figure 22 Visual inspection of a car (copyright Honda)

Another problem in the experiments by Li and colleagues is that, when consumers inspect certain products in stores, they want to do much more than only see the products from different angles (Peck and Childers 2003). For instance, when they evaluate a digital camera they may want to turn it on to see what appears in the LCD screen; they can then see what controls are available and how easy or difficult it is to take a picture, and even how to delete a picture from memory. They may compare different cameras, and also the pictures taken with them. All these tasks can and should be supported by multimedia experience, but cannot be by virtual experience. In other words, even though 3D visualisations, as in a virtual experience, can be very useful in certain contexts to support certain tasks, there is much more to multimedia experience than 3D visualisations. For example, they claimed that for a wristwatch, visual inspection is sufficient. This contradicts what consumers usually do when shopping for a watch: they try it out to see if they can understand all the controls. For example, in Figure 23 a multimedia experience of a sports wristwatch is illustrated. In this case, the user can click on any button, trying out functions such as alarm, timer, chronograph and heart rate monitor, and seeing the watch's reactions (e.g., changing its display or emitting a sound) as if it was the real watch.

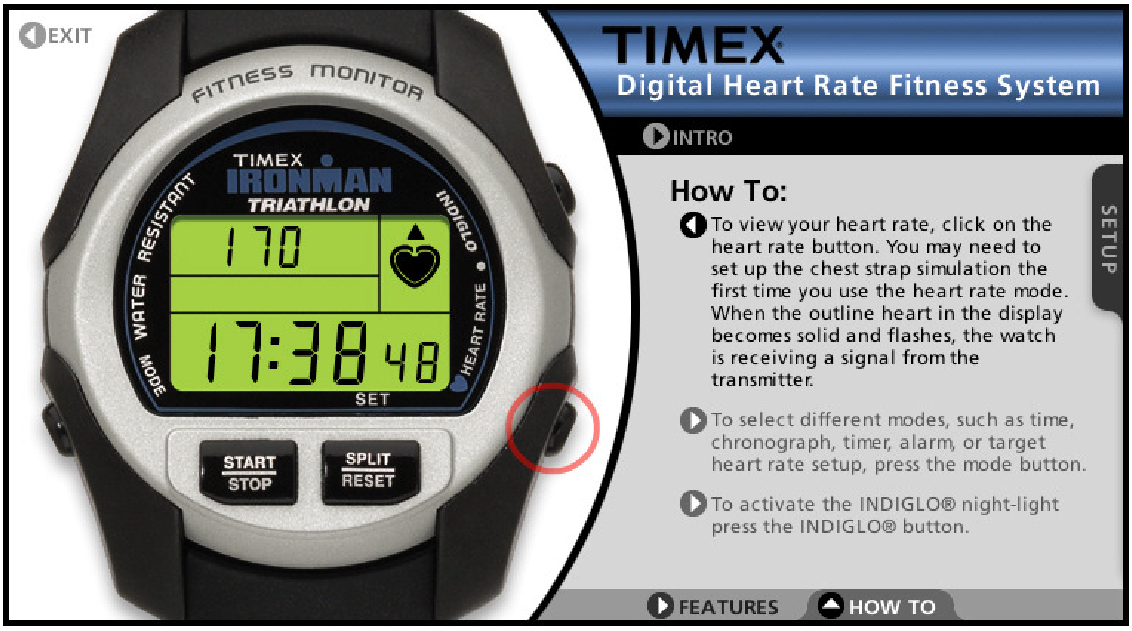

Figure 23 Multimedia experience for a wristwatch (copyright Timex)

The main goal of multimedia experience is to offer the consumer product experience to assess consumption experience, which is not possible with indirect experience. The key issue, then, is how to design a multimedia experience, supporting the consumer's exploratory behaviour so that he/she forms a good idea of the product without even touching it. In contrast to the 3D visualisations used by Li, Daugherty et al. (2001), this researcher proposes there be interactive and guided product demonstrations based on minimalist design (Carroll 1990) - the consumer would interact with the simulation in a similar way to how he or she would interact with the physical product in a direct experience. Multimedia experience supports both visual and functional inspection of products, as confirmed by Jiang and Benbasat (2004).

Multimedia experience allows the consumer to interact with and control the product. From studies by Ariely (2000), it is already known that a high control of product information increases the fit between the consumer's needs (heterogeneous and dynamic) and the information available (Jiang and Benbasat 2004), which means that the user explores and understands more of the information. This is in line with the multimedia exploration feature, as discussed in Chapter 4.

5.10 Types of product inspections

To make the distinction between 3D visualisation (virtual experience) and multimedia experience clearer, it is important to understand the different types of product inspection they each support. Li, Daugherty et al. (2002) reported three types of product inspection, each for a set of salient attributes:

1. **Visual inspection:** Consumers learn about the shapes, texture, and perceived functions of a product by moving their bodies or the product to visually inspect it from different angles. Visual inspection is used for products containing visually salient attributes – called geometric products (Klatzky and Lederman 1987) – consumers can select them satisfactorily by merely seeing them. Visual inspection is probably the most common affordance as consumers learn about shape, texture, and the perceived functions of a product through examination.

2. **Haptic or tactile inspection:** Tactile inspection is used for products composed of tactilely salient attributes, such as clothes or bedding material. These products have been called "material products" by Klatzky and Lederman (1987). Consumers desire to obtain further

information using their hands to touch and feel these products, in addition to visual inspection. Human hands can gain additional information by dealing with the temperature, texture, hardness, and weight properties that the products are composed of. Klatzky and Lederman (1987) found that, in extracting the haptic properties of objects we are interested in, we employ very specific hand movements, which they called “exploratory procedures”. Whether a consumer feels the need to directly experience a product haptically, will partially depend on the salience of material properties of the product. One factor that may affect the salience of haptic properties is product category variability with respect to material properties; if all products in a category have similar values across all their material properties, then their haptic attributes should not be highly salient. For example, most consumers perceive that the product category of clothing varies, depending on material attributes such as texture (or softness) and weight, and consequently it is more probable that consumers would want to directly experience these products through touch prior to purchase, compared with a product category such as CDs or books, where most people would not perceive product category variability of a material property (Peck and Childers 2003).

3. **Behavioural inspection (functional inspection):** the levers, buttons, and handles of products are affordances that suggest behavioural interaction. For instance, a consumer may want to turn on a smart phone to see the screen or examine how to input an address entry. To a certain degree, these behavioural interactions, called “function testing” by Klatzky and Lederman (1987), between consumers and products, can be simulated in a multimedia experience. In multimedia environments, animations can simulate direct experience, triggering product behaviours upon some user action, such as, clicking the mouse to open a laptop computer or to take a picture with a camera. Li, Daugherty et al. (2002) called these products “mechanical” products, and Klatzky and Lederman (1987) referred to them as “functional”. In the experiments conducted by Li, Daugherty et al. (2003) the only 3D model for which participants reported physical presence was the laptop computer; the reason given by the authors was that it was the only one with some (very limited) behavioural simulation (it was possible to turn the computer on and see one screen). Functional inspection is fundamentally different from visual inspection; functional inspection is related to how a product works, and visual inspection is related to a product’s appearance or form.

Li, Daugherty et al. (2002) claimed that if visual inspection is the determining cue, consumer learning should be enhanced over indirect experience by examining 3D virtual products. If tactile experience is the primary evaluation criterion, such as the case with the bedding material, the effectiveness of virtual simulations is limited. Yet, when behavioural simulations are salient for inspection, virtual experience may offer a unique opportunity for marketers to simulate action through animation and customisation. Despite the fact that Li and colleagues were mainly interested in examining visual simulation with very limited behavioural simulation, their conceptualisation of mechanical products, extending the previous geometric/material typology by Klatzky and Lederman (1987) (Table 11), can benefit further research (as is the case in this thesis which examines the challenging category of mechanical products).

Table 11 Properties of products and corresponding types of product simulation

Properties of products (Klatzky and Lederman 1987)	**Type of product simulation** (Li, Daugherty et al. 2003)
Geometric (visual attributes)	Visual simulation
Material (tactilely attributes)	Tactile simulation
Mechanical (Li, Daugherty et al. 2003) or functional (Klatzky and Lederman 1987)	Behavioural/functional simulation

Ariely (2000) found that high information control in e-shopping environments improves consumer decision quality and knowledge. Daugherty, Li et al. (2005) observed that offering the user control over the inspection of a product creates a virtual experience that is similar to direct experience, because consumers are able to inspect products from different perspectives at their own pace. This results in a stronger impact for experience attributes (compared to indirect experience). Nevertheless, the authors noted that the limited sensory input compared with that of direct experience is a major disadvantage of virtual experience. Consumers cannot touch, smell or taste a product on the computer before the technology to support such actions is available.

Daugherty, Li et al. (2005) showed that virtual experience is richer than indirect experience and closer to direct experience. The underlying reason is that virtual experiences allow for vicarious learning, because consumers are actively engaged in the inspection and control of a 3D product, as opposed to just passively observing as in more traditional forms of advertising. The authors explained that 3D simulations of products render mental images that are traditionally created by consumers interacting with physical products. This characteristic provides the sensation and feeling of “being there” with a product, due to, according to the authors, interactivity, vividness, personal relevance and a sense of presence when examining a 3D interactive product.

In another experiment (Daugherty, Li et al. 2005), 90 participants were divided in 3 groups, each exposed to a different presentation of a video camera: virtual, indirect and direct experience. In the virtual experience condition, a 3D website offered the ability to rotate and control product movement from different angles, to zoom in and out for detailed inspection, and used animation to simulate movement of the LCD display, identifying each component as the mouse moved over the product. In the indirect experience condition, a magazine advertisement was produced with the same content as the website. Finally, in the direct experience condition, the camera was presented with the same information given in the printed ad, functioning as a point-of-purchase display. Participants were instructed to evaluate the product and examine the materials for five minutes. A questionnaire measured product knowledge, brand attitude and purchase intention. To the researchers’ surprise, product knowledge was significantly higher in the virtual experience condition compared to direct experience[47]. Compared to indirect experience, the three measures were significantly higher in the virtual experience condition.

The researchers concluded that consumers experience the examination of products in a virtual experience as being richer than in an indirect experience, and closer to a direct experience, because the product description is combined with interactivity. So, virtual experience has the ability to moderate the advantages of indirect and direct experience, by producing a virtual product experience that simulates trial while also presenting information on search attributes.

[47] The other measurements – positive attitude and purchase intention - were also higher in the virtual experience condition, albeit not significantly.

The explanation given by the authors for virtual experience producing more product knowledge than direct experience was that participants could get more information clicking the mouse on specific components, while this was not possible in the direct experience. This can also be viewed as a flaw in the design of the experiment, as the amount of information was not kept constant across all three conditions. Furthermore, in the direct experience condition, participants were not able to touch and try out the camera, which puts into question the authors' conceptualisation of direct experience.

Having considered learning through direct and indirect experiences, proposed multimedia experience for consumer learning in e-shopping environments and seen different methods people employ to inspect products, the findings can now be summarised and implications both for design and for hypotheses examined.

5.11 Implications for design and for hypotheses

Based on findings from general consumer behaviour research and specific online consumer behaviour research, certain implications for the design of e-shopping applications can be presented to support the evaluation of alternatives as follows (each implication is allocated to the respective section(s) in the chapter):

- E-shopping systems should support the consumers' two main goals: minimise the cognitive effort necessary to make a choice and maximise the accuracy of the decision. These goals are related to time risk and performance risk, respectively (sections 5.5.3, 5.6).
- Users should be put in control of the interaction, by adapting the system to the decision rules they follow (5.5.2).
- In situations requiring extensive problem solving, for products with salient search and experience attributes, both indirect and multimedia experiences should be provided (5.5, 5.7, 5.8.3, 5.9).
- Comparison tools are essential to support the evaluation of alternatives (5.5.1, 5.5.2, 5.5.3, 5.7.1).
- Consumers should not only be able to compare search attributes, but also experience attributes (5.8.3).
- Comparison tools should only present information relevant to the decision to avoid information overload (5.5.4).
- Multimedia experience should be designed according to the type of inspection(s) needed for the product (visual, tactile and/or functional) (5.10).
- Multimedia experience should be designed to offer guided exploration (5.9).

In conclusion, how the use of multimedia product experience and comparison tools might improve e-shopping systems needs to be investigated:

The case for multimedia product experience

The ability for e-stores to overcome the users' need to physically see a product, in order to make a buying decision, is critical to the success of online shopping (Alba, Lynch et al. 1997). It is essential for consumers to be able to reliably predict the consumption benefits a product offers, and the way to do this in e-shopping is to design an environment where product information is faithfully reproduced, for both search and experience attributes. Providing consumers with useful product related information will increase their satisfaction with the shopping process and also the consumption satisfaction with the products they purchase (Lynch and Ariely 2000).

The case for comparison tools

Comparison tools can potentially support the stage of evaluation of alternatives in the consumer decision-making model, helping consumers to make more informed and accurate decisions. Smith, Johnston et al. (2002) pointed out that side-by-side comparisons make product evaluation easier, highlighting the differences between items. The downside of side-by-side comparisons is that they may cause information overload, and, as a result, cause slower and more error-prone choices. On the other hand, not using side-by-side comparisons can likewise produce poor choices, since it also creates information overload. The implication for design, therefore, is to allow consumers to compare only attributes that are relevant to the decision. Decision-relevant information will vary depending on the consumer, the product, and the situation, which means that the consumer should be able to control the comparisons, choosing the evaluative criteria needed for the task at hand.

The ability to make comparisons is considered one important risk reliever related to performance risk (Cases 2002). This was confirmed by Lynch and Ariely (2000) where subjects opted for cheap wines as a way to relieve financial risk, but when presented with comparison tools they became less price sensitive and made more informed choices. Lynch and Ariely concluded that the support of comparisons gives consumers the ability to increase the consumption utility of the products.

One strength of online shopping is in the customer’s ability to quickly compare similar products to make on optimal choice (e.g. highest quality, price, etc.) (Alba, Lynch et al. 1997). E-shopping environments should be designed to allow consumers to tailor the basis for comparison of alternatives, in order to make the system compatible with the process by which consumers prefer to make decisions.

The case for the combination of multimedia experience and comparison tools

Hoch (2002) pointed out that the vivid nature of experience tends to reduce the perceived need for comparison. The consequence is that product experience is more likely to be evaluated in an absolute sense (feels “good” or “bad”), without concern for relevant parameters. Given that experience increases decision confidence (Muthukrishnan 1995), overconfidence will work against the consumer, particularly when product experience is readily available. Hoch (2002) added that personal experience is overrated. He believed that consumers put too much trust in what they learn from experience and that they become seduced by the very nature of a particular activity. The problem, according to Hoch, is that they believe they have learned more from product experience than they actually have, and that they do not need any further information. Other researchers have confirmed that consumers associate high validity with judgements that are based solely on direct experience (Fazio and Zanna 1981; Smith and Swinyard 1983; Muthukrishnan 1995). According to Muthukrishnan (1995), in some cases experience alone may inhibit rather than facilitate learning. This happens, according to the author, in environments that do not facilitate comparisons between products. Therefore, the availability of both multimedia experience and comparisons is essential for users of e-shopping systems.

Some hypotheses that have been generated by this review are presented below.

- Indirect experience combined with multimedia experience will produce better consumer choices than indirect experience alone.
- The presence of comparison tools will produce better choices than when they are absent.
- Comparison tools will reduce the time taken to reach a decision.

- Multimedia experience will have a positive effect on product learning compared with indirect experience.
- Multimedia experience and comparison tools will reduce perceived product risk and, consequently, increase consumer satisfaction.

5.12 Final remarks

The background research presented in this chapter has provided important insights that have shaped the work to be expounded in the remainder of this thesis:

1. Relatively little work has been done in online consumer behaviour, especially within the framework of the HCI discipline.
2. Research in consumer behaviour can be useful and necessary in generating hypotheses for empirical testing.
3. The main challenge with e-shopping in extensive problem solving is how to reduce perceived product risk.
4. It is essential to give consumers control over the interaction and not to impose any particular rule for decision making.
5. The utility and usability of multimedia technology has not been adequately investigated, particularly with regard to learning about products with salient experience attributes.
6. Products differ in terms of the type of inspection needed for consumer assessment.
7. Behavioural inspection for mechanical products has not been adequately investigated.

In the following chapter, the experimental hypotheses on multimedia and comparison tools are presented.

Chapter 6 Hypotheses Development

Explanation is the aim of science, and hypothesis-testing using empirical data is its central method.

Robin Dunbar, The Trouble with Science (1995)

6.1 Introduction

In order to fully understand the impact of multimedia product demonstrations and comparison tools in consumer decision-making in an e-shopping environment, they must be empirically tested. Potentially the findings and their implications could enhance consumer experience, providing designers (and marketers) with a basis for building e-shopping environments that are effective and helping consumers make more informed decisions, in an easier way. This chapter is organised in two parts: first, in section 6.2, Multimedia (MM) and Comparison Tools (CT) are discussed in terms of their hypothesised effects on e-shopping. Section 6.3 presents then a set of testable predictions that can be made.

6.2 Multimedia and Comparison Tools – effects on e-shopping

6.2.1 Multimedia

The previous chapter showed how multimedia technology can be used to allow consumers to interact with a representation of the product, prior to purchase. An interactive multimedia product experience (IMPE) can be considered an intermediate representation situated between indirect and direct product experience. So, while multimedia product experience is mediated, like indirect experience (e.g., brochure, advertising), it potentially shares many of the advantages of a direct experience, in which evidence is self-generated and more trustworthy, and the consumer can manage the focus and pace of an inspection.

In a study using protocol analysis, Li, Daugherty et al. (2001) found that consumers consider a product presented as a 3D model as looking realistic. However, their data shows that, in fact, only 37 percent of the participants had this opinion. This low percentage may be due to the fact that the participants could only move, rotate and zoom the 3D product models. They also reported becoming frustrated because the interaction with the virtual products involved only control of its visual properties; they expected additional interactive features to be available allowing them to inspect the product (e.g., to open a virtual laptop computer). The authors concluded that "by incorporating all relevant interactive features for a specific type of product, advertisers and marketers may be able to minimise any negative feelings resulting from unmet expectations in virtual environments" (Li, Daugherty et al. 2001, p. 26).

This thesis claims that the perception created by IMPE promotes consumer learning, and hence potentially impacts on their ability to evaluate the product more fully, if compared to an indirect experience like static multimedia product presentation (SMPP).

The multimedia features can all be applied to design an IMPE for the purpose of visual and functional inspections. For example, the naturalness feature indicates that the representation of the product must be believably realistic. As will be detailed in the next chapter, a product like a digital camera requires that its physical properties (colour, size, shape, material) and its behaviour are represented. This means that if the zoom control is pressed, then the image in the camera display must change accordingly. If the shutter button is pressed to take a picture, than the typical sound and action is expected to be heard, and seen. The exploration feature indicates that the controls and manipulations of the real product should be mapped into the multimedia representation in order to give the consumer a good idea of the operations of the product. Using the same digital camera example, it should allow the user to "experiment" with the product by changing the settings, adjusting the zoom control and taking a picture, typical activities a consumer would hope to perform while examining and inspecting this product in a traditional shop.

Nisbett and Ross (1980) claim that when a direct experience happens, doubts about the validity of the information are reduced and the personal relevance of the information is enhanced. Alba, Lynch et al. (1997) argue that the move from indirect to more direct experiences increases the confidence a consumer will have in the correlation between the observed attributes and actual product benefits. Information becomes more useful in terms of their potential to predict satisfaction from subsequent consumption. As pointed out by Klein (1999), when a consumer has greater confidence in her ability to predict satisfaction, she will learn more and have more confidence in what she learns.

To sum it up, IMPE should produce effects that are situated between indirect and direct experiences.

6.2.2 Comparison Tools

Jarvenpaa (1989) cites several studies that demonstrate that the format used to present information affects decision outcomes by influencing information acquisition and processing. The presentation format may even change the methods by which people acquire and combine information to make decisions. For choice tasks with multiple alternatives described by the same set of attributes, the presentation can be organised by *alternatives*, by *attributes*, or by a *matrix* of alternatives and attributes (Table 12). In an *alternative* organisation, the values of all attributes for only one alternative are presented. With an *attribute* organisation, the values of the same attribute for all alternatives are presented separately. And in the *matrix* organisation, the alternatives are organised in columns with each line being the value of each attribute.

Table 12 Formats to present attribute information

Presentation Organisation	Characteristics
Alternative	Values of all attributes for only one alternative
Attribute	Values of the same attribute for all alternatives
Matrix	Alternatives in columns and values of all attributes in each line

People follow two different strategies while acquiring and combining information: alternative and attribute processing (Jarvenpaa 1989). In alternative processing, information is processed on several attributes of one alternative, before the next alternative receives the same processing. In attribute processing, information is processed on one attribute for several alternatives, before the next attribute receives the same processing. Alternative processing is used when information is organised by alternatives, and attribute processing is used when information is organised by attributes (Jarvenpaa 1989). When information is organised in a matrix, both alternative and attribute processing take place.

As Jarvenpaa (1989) noted, the display format influences the cognitive demands on memory and attention when people acquire information as well as when they evaluate information. The strategy selected is then a compromise between the benefits of maximising accuracy and minimising the cognitive effort in a particular task environment. Therefore, the way information is presented affects cost-benefit trade-off by making some strategies easier to use than others. For example, an alternative format facilitates a strategy based on alternative comparisons, and likewise, attribute format facilitates comparisons of attributes. Consequently, the format in which information is presented may not support the processing demands of the decision task.

Jarvenpaa uses the term incongruence to refer to situations where the decision strategy and the presentation format are in conflict. The "cost/benefit approach", i.e. choosing the strategy that requires the least effort to achieve a satisfactory solution, suggests that incongruence must invoke some cost, either in increased time (effort) or in decreased accuracy, or both.

Previous studies on product comparisons concentrate on search attributes only. However, a consumer can also make comparisons of experience attributes in at least two ways:

- Comparison of performance - this is normally accomplished through direct experience, assessing and comparing the overall performance of the products. For example, if the product in question is a printer, one of the activities involved in assessing their performance is comparing the same printouts from alternative printers (Figure 24). If the product is a set of speakers, comparing their sound quality by playing the same audio. As explained in Chapter 5, direct product experiences are more credible and considered the trustworthiest for a consumer.
- Comparison of functionality - one of the activities consumers engage in a shop is experiencing the product, comparing its usability with its alternatives (if the shop happens to have them in stock or, if not, doing this across shops and relying on memory and notes made), evaluating their operation side-by-side (e.g., for MP3 players, how to find a song or how to tune into a specific radio station, for example).

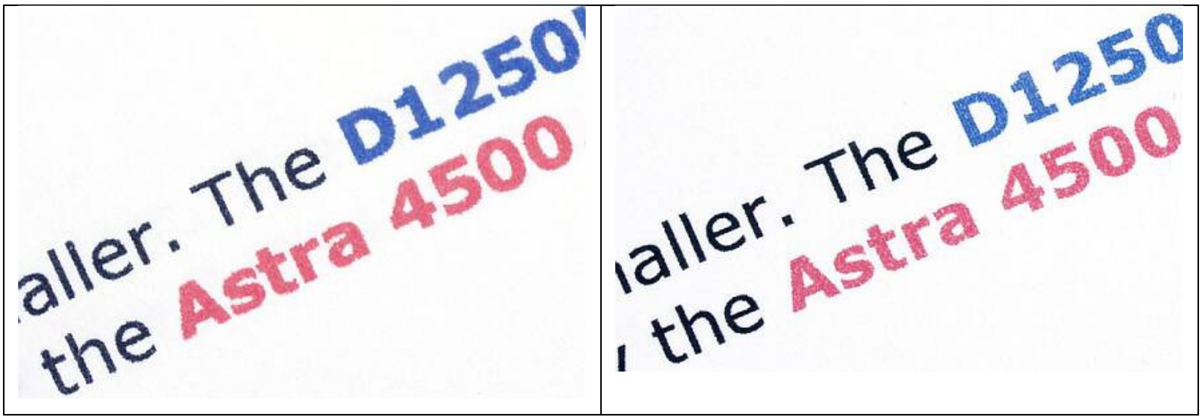

Figure 24 Comparing output quality of different printers[48]

In supporting shopping activities for complex products, support for comparisons of both search and experience attributes will improve consumers' ability to compare and assess products and hence is likely to have an effect on the quality of the decisions they make.

6.3 Experimental Hypotheses

This section presents a set of hypotheses about how the dependent variables are affected by each of the two independent variables MM and CT. The dependent variables attempt to capture the user-experience; they are grounded both on usability measures (effectiveness, efficiency and satisfaction) and on consumer behaviour measures (learning, attitudes, beliefs, perceived quality of decisions, perceived knowledge). Naturalness is also measured.

[48] This figure represent the output quality of different printers, which is more noticeable on the screen than on paper.

Each hypothesis is introduced by a rationale for it and is stated in terms of the expected difference, everything else being equal, between a scenario in which IMPE is used and CT is present in an online shopping trip for a complex decision-making and a scenario where SMPP is used, and CT is not present.

6.3.1 Decision Quality - effectiveness of decisions

The only study known to this researcher in which purchase decision quality was measured was conducted by Haubl and Trifts (2000); what Li, Daugherty et al. (2003) describe as decision quality is, in fact, perceived decision quality[49]. In the present study, decision quality is measured by the score on decisions taken for the tasks.

It has been shown in the literature (Hoch and Deighton 1989) that direct experience with a product (and its alternatives) can increase the quality of the decisions taken. Since in an e-shopping environment the consumer cannot manipulate the product directly, providing a more directly mediated way to interact with the product and its alternatives should lead to better decisions compared to a situation where this information is provided indirectly (through static pictures and text). Thus we hypothesise that

> *H1a: IMPE will increase the quality of the decisions.*

Decision quality is also affected by the format a list of products is presented to consumers. An alternative organisation supports alternative processing but does not support attribute processing. This also means that it is not possible to compare attributes. In a matrix organisation, both alternative and attribute processing are supported, through the use of CT. CT should enhance the ability to process information for decisions that involve several attributes. It is expected that CT will assist participants in making in-depth comparisons and, as a result make better decisions. Comparing product performance and usage will give the consumer a better prediction of satisfaction. Therefore, we hypothesise that

> *H1b: The presence of CT will increase the quality of the decisions.*

6.3.2 Learning

Learning can be defined in many different ways; for this thesis, it is the process by which new information is acquired, while memory is the process by which that knowledge is retained. If the process of learning varies according to the use (or not) of IMPE and CT, it will be possible to see its effect by measuring the amount of knowledge and understanding that is learned.

Consumers usually learn about products through both direct experience (e.g., trial or inspection), and indirect experience (e.g., brochures or advertising). In the SMPP condition, knowledge will be acquired by description through indirect experience. On the other hand, in allowing the consumer to experience the product virtually, the IMPE condition is closer to direct experience, in which knowledge is acquired by acquaintance. It is already established that direct experience promotes learning and, consequently, better memory (Hoch and Deighton 1989), because information is more vivid and concrete (Paivio 1991) and because it requires more elaborative internal rehearsal and self-generation (Hoch and Deighton 1989). So, if IMPE provides a product experience that is closer to direct experience, we expect that the same effect should happen with a multimedia experience.

We hypothesise that

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[49] Perceived decision quality is also important and will be discussed in section 6.3.9.

H2a: IMPE will improve learning.

CT will make information integration more accurate and consistent. It reduces the cognitive effort to make comparisons across products; therefore, the free resources can potentially be utilised for learning. Hence, it is expected that

H2b: The presence of CT will improve learning.

6.3.3 Time and Efficiency

Time reflects the amount of search for product information; it is determined by consumers' uncertainty about the absolute utility associated with an alternative and about the relative utility of alternatives in a set (Haubl and Trifts 2000). In an electronic shopping environment, the amount of information search is also dependent upon the consumer's ability to identify and evaluate alternatives' information effectively (Alba, Lynch et al. 1997; Bakos 1997). Time has traditionally been considered the major cost factor for consumers while searching for information (Spiekermann 2001).

Because of its interactive nature, IMPE offering the possibility of virtually experiencing the products, will increase the necessary time to evaluate the products and, consequently, to make a decision. A parallel effect also takes place in traditional shopping: it has been shown that direct product experience takes more time than indirect product experience (Schlosser 2000).

Another difference between the IMPE and the SMPE conditions is the range of possibilities to navigation, or the number of possible actions at any given time. This is much greater in the IMPE condition for the inspection of products.

H3a: IMPE will increase the time to reach a decision.

CT allow consumers to compare products in a very efficient manner, due to its capability of organising product information (Haubl and Trifts 2000). It then becomes easier to determine the relative merits of alternatives. The lack of CT forces the consumer to make comparisons using information s/he can remember; whereas with CT we move from a predominantly memory-based[50] choice to a recognition-based one (Alba, Lynch et al. 1997; Kardes 2003). Thus, the use of CT should reduce the combined marginal cost of acquiring and processing attribute information about an alternative (Haubl and Trifts 2000):

H3b: The presence of CT will reduce the time required to reach a decision.

Related to decision quality and time, efficiency is measured by dividing the number of correct decisions by the total time spent on the tasks.

Direct product experience is generally considered less efficient than indirect product experience (Schlosser 2000). So, if multimedia experience is closer to a direct experience than to an indirect experience, it can be expected that participants in the IMPE conditions will behave in the same way.

H4a: IMPE will reduce efficiency.

Since in H1b it is predicted that decision quality will improve, and in H3b, that time will decrease, it can be hypothesised that

H4b: The presence of CT will improve efficiency.

[50] It can be argued that in this particular situation, choice is not 100% memory-based, since some of the relevant information is directly observable and some information must be retrieved from memory. In this case, we can use the term *mixed choice (Kardes 2003).*

6.3.4 Satisfaction

Some studies in the HCI literature report a correlation between satisfaction and efficiency (Nielsen and Levy 1994). Nevertheless, in two important meta-analysis studies, Frokjaer and colleagues (Frokjaer, Hertzum et al. 2000), and Hornbæk and Law (2007) have demonstrated that this assumption does not necessarily hold true, especially for non-routine or complex tasks in the case of the analysis by Frokjaer and colleagues.

End-user satisfaction is widely used as a surrogate for information technology success (Lightner and Eastman 2002). A meta-analysis of empirical literature (45 papers) on the use of end user satisfaction found it to be a fundamental measure to explain why some systems fail and others succeed (Mahmood, Burn et al. 2000).

In the context of the current study, by making the product inspection more congruent to consumers' expectancies in the IMPE condition, satisfaction is expected to be higher.

> *H5a: IMPE will make participants feel more subjectively satisfied with the website.*

The same rationale is valid for CT, where consumers are expected to be more satisfied with the shopping experience.

> *H5b: The presence of CT will make participants feel more subjectively satisfied with the website.*

6.3.5 Perceived ease of use

Much previous research has established that perceived ease of use is an important factor influencing user acceptance and usage behaviour of information technologies in general (Davis 1989; Venkatesh and Davis 2000).

Perceived ease of use refers to the extent to which an individual believes that using a particular product or system would be free from physical and emotional effort (Venkatesh and Davis 2000). Perceived ease of use has been shown to be directly related to user's acceptance of technology (Morris and Dillon 1997). It is essentially related to the interactive functions of a product.

Well-designed multimedia is expected to be perceived as easier to use. In this respect, allocated media that is congruent with the task users perform is likely to produce an experience that is easier to use.

Based on this, therefore, we hypothesise that

> *H6a: IMPE will make participants perceive the website as being easier to use.*

It has been shown in the literature (Jarvenpaa 1989) that the presence of comparison tools affects the way consumers process information about products. The lack of comparisons increases the cognitive effort as users need to remember information about alternatives that is not shown on the screen. This is related not only to the list of attributes for the alternatives, but also to the pairwise comparisons of the functioning of a product, and to its performance. Basically, if users' comparison tasks are better supported, then the experience will be perceived as easier to use. Hence,

> *H6b: The presence of CT will make participants perceive the website as being easier to use.*

6.3.6 Naturalness/realness

One of the most important dimensions of multimedia is the differential level of realism that it is able to provide. In a consumer decision making context, a central requirement is to allow the consumer to experience product performance prior to usage; however an important characteristic of e-shopping is that the physical product is not present. As already noted, products in which most dominant attributes are experience are best assessed by direct experience. So, a well-designed product multimedia experience that puts the consumer closer to a direct experience than to an indirect product experience will increase credibility in the assessment of a product. The importance of naturalness in consumer behaviour can then be stated as: the greater the naturalness of a multimedia product experience, the closer to direct experience a consumer will perceive. Naturalness and realness have a positive impact in the confidence a consumer will have in the correlation between the observed attributes and actual product benefits (Alba, Lynch et al. 1997).

> *H7a: IMPE will make participants perceive the website as being more natural/closer to reality to interact with.*

Since comparison tools are not related to product experiences, they should not affect naturalness and realness measures.

> *H7b: The presence of CT will not affect the way participants perceive the website as being more or less natural/closer to reality to interact with.*

6.3.7 Attitudes

Attitude is central to any discussion in consumer-behaviour and there are several different definitions. The main point, shared by most definitions, is related to its evaluative nature (Keinonen 1998). As Fishbein and Ajzen (1975) remark, attitude can be defined as “a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object” (p. 6).

Ajzen and Sexton (1999) claim that attitudes are preparatory to behaviour; attitudes predispose individuals to decisions and actions consistent with the valence of the attitude. Positive attitudes are expected to produce an approach tendency, and negative attitudes to produce an avoidance tendency. According to Fishbein and Ajzen (1975), a person’s overall attitude towards an object is determined by the subjective values or evaluations of the attributes associated with the object, as well as by the strength of these associations.

Despite its prominent place in consumer-behaviour research, little is understood about the impact of attitudes on e-shopping (Teo, Lih-Bin et al. 2003; Lee, Hong et al. 2004). User attitude is important because it contributes to user’s intention to use the web for shopping (Ajzen and Sexton 1999), while user’s intention is considered to be a good predictor of behaviour (Davis 1989; Ajzen 2005). Notably, attitude appears to be a significant factor to electronic shopping: purchase intentions[51] are found to get better as attitude towards the website improves (Chen, Chen et al. 2007). Furthermore, as remarked in Chapter 5, there are indications of a strong link between perception of risk and attitudes (the more risk is perceived, the greater negative attitude is built), culminating on an effect on behaviour (decreasing the chance of purchases) (Swaminathan, Lepkowska-White et al. 1999; Bhatnagar, Misra et al. 2000; Heidjen, Verhagen et al. 2001; Lowengart and Tractinsky 2001).

One of the best known attitude models is the Fishbein multi-attribute attitude model (Fishbein and Ajzen 1975; Fazio and Towless-Schwen 1999). In this model, attitude towards an object is the sum

[51] Purchase intention is a complex construct on its own and could depend on many different considerations such as price, need, desire, design, priority, etc. It will not be examined in detail as it is beyond the scope of this thesis.

of products of the evaluated values of attributes and the strength of belief that such attributes are in the object. The basic structure of the model is shown in the following equation:

$$A=\sum_{i=1}^{n} b_i e_i$$

In this equation, A is the attitude toward the object; b_i is the strength of the belief (the subjective probability) that the object has attribute i; e_i is the evaluation of attribute i; and n is the number of salient beliefs (Fishbein and Ajzen 1975).

Although behaviour cannot be predicted solely based on attitudes, they are a major factor[52]. The behaviour in question in this case is both the decision to purchase online and the choice of a specific product. Attitudes are mental constructs that cannot be directly observed, but are deduced from human responses. The responses may be verbal or non-verbal, related to beliefs, emotion or behaviour.

Attitudes towards products are formed through direct experience or from secondary sources such as advertisements or word-of-mouth (Keinonen 1998). Fazio and Zanna (1981) point out that "…attitudes formed through direct experience are stronger than those formed through indirect experience. ... direct experience attitudes are more clearly defined, held with greater certainty (confidence), more stable over time, and more resistant to counterinfluence" (p. 185). Assael (1998) agrees that lack of product (direct) experience results in weakly held attitudes.

There are two possible reasons for this difference according to Fazio and Zanna (1981). These are:

1. Salience of behavioural information: information processing difference may exist between direct and indirect experience. In a direct experience, the behaviour itself is salient to the individual, while in an indirect experience the description of the attitude object becomes more salient. Focus on behavioural information tends to facilitate the ease with which one can decide on one's attitude.

2. Attitude accessibility: attitudes based on direct experience may be more accessible from memory than attitudes based on indirect experience.

In online environments, if consumers can experience and evaluate products in a way that is closer to physical shopping environment, attitudes could be stronger when compared to indirect experience (Jarvenpaa and Todd 1996). If consumers believe that a product experience is more diagnostic, it is likely that their attitudes about the product will be stronger and held with more confidence (Kempf and Smith 1998; Jiang and Benbasat 2007). Therefore improving consumers' cognitive evaluation of products, including being able to compare products side-by-side, should lead to stronger positive attitudes toward the website and the products.

H8a: IMPE will make participants have stronger positive overall attitudes formed in relation to the website and the products.

H8b: The presence of CT will make participants have stronger positive overall attitudes formed in relation to the website and the products.

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[52] Ajzen and Fishbein (1975) have developed quantitative models to describe the influence of many of these factors in predicting behaviour. In addition to attitude, behaviour is also influenced by a subjective norm. The subjective norm is a factor that takes into consideration the influence of relevant others (social environment) on the individual's decisions. On top of attitude and subjective norm, the theory of planned behaviour (Ajzen 2005) adds a third factor: perceived behavioural control - the perceived ease of reaching the aims, influenced by the subject's abilities, skills, emotions, or dependence on others.

6.3.8 Beliefs strength

A belief, as defined by Fishbein and Ajzen (1975), is the subjective probability that the object[53] has a certain attribute. In consumer behaviour, beliefs are cognitive constructs linking product properties to consumer's ideas (Keinonen 1998). Beliefs strength measures how strong these beliefs are, i.e., the subjective probabilities of object-attribute associations.

Belief-based attitude hierarchies are often based on multi-attribute attitude models. In a decision making situation, only the salient beliefs are accessible. People evaluate the attributes, give them weights, and sum the scores either consciously or unconsciously.

The strength of the beliefs will determine their accessibility, their salience, and in turn the basis for attitude formation. Of course, it is not possible to measure all beliefs associated with several products, but a good approximation of their relative strength can be obtained by selecting a sample of products/attributes.

In the electronic shopping context, it can be defined as consumers' subjective evaluation of a relevant object such as the Internet as adequate for shopping, a specific electronic store, an online shopping experience and/or a class of products (or a specific one) being sold in an e-shop. Beliefs are expected to impact a consumer's shopping intention, behaviour, and satisfaction (Li and Zhang 2006).

From consumer behaviour literature, individuals who have had direct experience with products in order to perform a behavioural inspection are likely to form beliefs about the behaviour's consequences and constraints that are more realistic than the beliefs of individuals who have only received second-hand (indirect) information about the behaviour. Direct experience is therefore likely to promote congruence between beliefs that are accessible at the time of attitude measurement and beliefs that become available during behavioural performance (Ajzen and Sexton 1999). And, indeed, attitudes are consistently found to predict behaviour better under conditions of direct experience (Fazio and Zanna 1981).

As Smith (1993) concludes, "because people rarely discount the trustworthiness of their own experiences, trial-based beliefs tend to be strong and/or confidently held." Compared to indirect experience, we can hypothesise that

> *H9a:* *IMPE will make participants hold stronger beliefs towards the products.*
>
> *H9b:* *The presence of CT will make participants hold stronger beliefs towards the products.*

6.3.9 Perceived quality of decisions

Because products cannot be examined directly, perceived quality of decisions becomes an important factor to be understood for the success of online shopping. It affects issues of confidence in choice and in future use of these environments.

Shoppers using MM will be more confident in their purchase decisions after experiencing the product. Confidence has been linked empirically to the direct/indirect experience by Fazio and Zanna (1981). These researchers state that confidence, and hence perceived quality of decisions, is greater in direct-experience conditions than in indirect experience conditions: "we often trust what we see and hear with our own eyes and ears more than we trust what we hear from other people" (Kardes 2003, p. 97).

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[53] The term "object" is used here in the generic sense, and refers to any discriminable aspect of an individual's world.

Therefore, the challenge in e-shopping is to overcome the consumers' interest in physically seeing and touching a product in order to make a buying decision (Alba, Lynch et al. 1997). This is less important for simple or inexpensive products (e.g. songs and books) or for the ones purchased as habit (e.g. cereals), but is a major issue for products that require complex decision making. Consequently, is it possible to provide information and create an environment that appropriately reproduce descriptive and, most importantly, experiential product information (Alba, Lynch et al. 1997) so as to decrease uncertainty? If this is accomplished, then being able to predict the consumption experience of the product through a virtual trial will make consumers more confident.

> *H10a: IMPE will make participants perceive their decisions as being of a better quality.*

Shoppers using CT will be very much aware of the positive impact on their own decision making ability. In this scenario, where choice is recognition-based, as opposed to memory-based, it is expected that CT will increase consumers' confidence in (i.e., reduce their uncertainty about) the choice they make (Haubl and Trifts 2000). Since comparisons minimise the possibility of regret over choosing a suboptimal product, it is expected that CT will make participants more satisfied with the decision process. Lynch and Ariely (2000) go further and state that the presence of CT has a positive impact on consumer's evaluation of an electronic store.

In addition to descriptive information, being able to compare diagnostic information is also important. By making it possible to easily compare product performance and usage should reduce uncertainty and increase confidence with the decision. Hence, it is hypothesised that

> *H10b: The presence of CT will make participants perceive their decisions as being of a better quality.*

6.3.10 Perceived knowledge

Consumer knowledge can be distinguished by two constructs. The first is objective knowledge, that is, accurate product information (related to hypotheses H2a and H2b). The second is perceived (self-assessed) knowledge or subjective knowledge: people's perception of what or how much they know about a product or product class (Park, Mothersbaugh et al. 1994). Although perceived and objective knowledge are related, it has been shown that they are distinct and should be considered separately (Park, Mothersbaugh et al. 1994).

Park, Mothersbaugh et al. (1994) showed that product experiences influence perceived knowledge of the product class. One explanation they give for the ease with which product-related experiences are retrieved is that they are more vivid in memory. Also, personal experiences with products lead to an increase in the perceived validity of information and an increase in the personal relevance of the information. Since IMPE is used to simulate direct experiences with the products, we hypothesise that

> *H11a: IMPE will make participants perceive they have a better knowledge of the products.*

The search for product information is directly linked with subjective product knowledge. The main factor is the quality of the information source, including organisation of the information (Park, Mothersbaugh et al. 1994). The possibility of comparing not only product search attributes, but also experience ones (performance and usage), will require less processing to reach decisions, and will lead to a feeling of better knowledge. Thus, we hypothesise that

> *H11b: The presence of CT will make participants perceive they have better knowledge*

of the products.

6.4 Summary

This chapter presented important hypotheses that are to be tested. It discussed the main effects that can be obtained by employing IMPE and CT in e-shopping environments. It started by identifying the two independent variables MM and CT and the expected effect they have on important variables related to consumers' behaviour. It then established how these effects should take place in terms of hypothetical outcomes. The hypotheses are:

H1a: *IMPE will increase the quality of the decisions.*

H1b: *The presence of CT will increase the quality of the decisions.*

H2a: *IMPE will improve learning.*

H2b: *The presence of CT will improve learning.*

H3a: *IMPE will increase the time to reach a decision.*

H3b: *The presence of CT will reduce the time required to reach a decision.*

H4a: *IMPE will reduce efficiency.*

H4b: *The presence of CT will improve efficiency.*

H5a: *IMPE will make participants feel more subjectively satisfied with the website.*

H5b: *The presence of CT will make participants feel more subjectively satisfied with the website.*

H6a: *IMPE will make participants perceive the website as being easier to use.*

H6b: *The presence of CT will make participants perceive the website as being easier to use.*

H7a: *IMPE will make participants perceive the website as being more natural/closer to reality to interact with.*

H7b: *The presence of CT will not affect the way participants perceive the website as being more or less natural/closer to reality to interact with.*

H8a: *IMPE will make participants have stronger overall attitudes formed in relation to the website and the products.*

H8b: *The presence of CT will make participants have stronger overall attitudes formed in relation to the website and the products.*

H9a: *IMPE will make participants have stronger beliefs towards the products.*

H9b: *The presence of CT will make participants have stronger beliefs towards the products.*

H10a: *IMPE will make participants perceive their decisions as being of a better quality.*

H10b: *The presence of CT will make participants perceive their decisions as being of a better quality.*

H11a: *IMPE will make participants perceive they have a better knowledge of the products.*

H11b: *The presence of CT will make participants perceive they have a better* *knowledge of the products.*

In order to test these hypotheses, the next chapter describes a system that was built with this in mind.

Chapter 7 System Design

One must learn by doing the thing
For though you think you know it
You have no certainty until you try.

Sophocles

7.1 Introduction

The aim of this chapter is to present the design of the e-shopping system used for the experimental work and the application of the design features. First, a brief explanation is given about the product choice: digital cameras. Then the tasks associated with rational decision making while shopping for digital cameras, and their requirements in terms of media are identified. The multimedia features presented in Chapter 4 are then used to inform design. Finally, the structure and navigation of the website are described.

The system built serves two purposes. First of all, it acts as a prototype system to test hypotheses. Moreover, the process of designing and building it allows us to assess the applicability of the design criteria described in Chapter 4. Before describing the system design, the chosen product class, digital cameras, needs to be justified.

7.2 Selection of the product class

Earlier studies comparing direct and indirect shopping experience have indicated that a pre-requisite must be met in the selection of the product to be used in the experiments: the product must have salient attributes, which can be evaluated by means of a trial (Smith and Swinyard 1983), where consumers assess some experience attributes through an inspection. Also, it should be noted that if users are to search for information, to evaluate products and to make a choice, a product that yields to complex decision making activities is needed (Assael 1998). According to Assael (1998), complex decision making is most likely required for:

- High-priced products
- Products associated with performance risks (medical products, cars)
- Technologically complex products (CD players, computers)
- Products associated with one's ego (clothing, cosmetics)

Assael also points out that adequate time for extensive information search and processing is a facilitating condition. Another condition for complex decision making is the availability of adequate information to evaluate the alternatives. An important pre-requisite for product choice is related to its properties: a mechanical object which can be inspected by functional manipulation in addition to visual inspection for geometric attributes.

The shopping system described here uses the digital camera as the selected product; it is technologically complex enough to be considered a risky purchase (Bhatnagar, Misra et al. 2000), and it is not something inexpensive. In terms of dimensions of perceived risk, digital cameras carry a high level of performance risk (Spiekermann 2001). Furthermore, it is a product class with approximately equal balance of important search and experience attributes, and therefore has equal needs for direct and indirect experiences (Wright and Lynch 1995).

The assumption of an equal balance of search and experience attributes was proven correct by Spiekerman (2001) for compact analogue cameras, where 119 people were asked "How comfortable are you that, with the help of the Internet, you'll be able to fully judge on all quality characteristics important to you in the compact camera? (1= not at all comfortable (2,3,4,5) 6= very comfortable)". The mean value found was 3.81. For the question "Please indicate, how probable it is that in the context of an Internet purchase you'll be able to fully judge on all quality characteristics of compact camera? (1= not at all probable (2,3,4,5) 6 = very probable)" the mean value found was 3.36. To interpret the results, a search product would tend to produce answers towards 6 – very comfortable and very probable, respectively, whereas an experience product would have answers closer to 1 - not at all comfortable and not at all probable, respectively. The results being between 3 and 4 confirm the idea that cameras have an approximately balance of search and experience attributes. The product tested in Spierkermann's study was a compact analogue camera, but given that the digital camera is a more technologically modern product, it can be assumed that the numbers are similar to the ones found in that study.

The e-store developed for the present study sells 11 models of digital cameras of the same brand, so as not to introduce a confounding variable: brand preference.

7.3 Shopping for digital cameras

As shown in Chapter 5, shopping is a complex activity, and it is the same with shopping for digital cameras. Although hedonic values play an important part in the shopping experience, for this thesis the main focus is the utilitarian value of shopping where a more cognitive, task-oriented outcome is expected.

In order to understand the tasks that must be performed to accomplish the goal of the activity, it is necessary to understand the tasks people perform either in physical stores or online, and then map these into a set of tasks that are implemented in the context of the user experience. For example, the following problem scenario describes a scenario that is relevant for design:

John's wife is pregnant with their first child. Since they live quite far away from both their parents, John would like to send them pictures of their grandchild. Also he would like to take as many pictures as possible of his son/daughter. So he wants to purchase a digital camera. John wants the best camera he can afford, as he doesn't want to be disappointed with the quality of the pictures. However, the camera has to be simple enough for his wife to use - she just wants to point and shoot. With his hectic life, John wants to purchase it online – he usually doesn't trust the advice given in shops and he knows that shops don't stock all available models. On the other hand, he prefers to try out and compare some cameras before making a purchase decision. In addition he wants to see sample pictures of the cameras as he believes "the proof of the pudding is in the eating", and he wants to read reviews about the cameras.

From this scenario it can be seen that an interactive system to support the shopping tasks in question needs to address not only the supply of product information, but also the means for comparisons and assessments, so that customers are able to make informed purchase decisions and select a camera that satisfies their needs. This follows a typical decision-making process model (Figure 25).

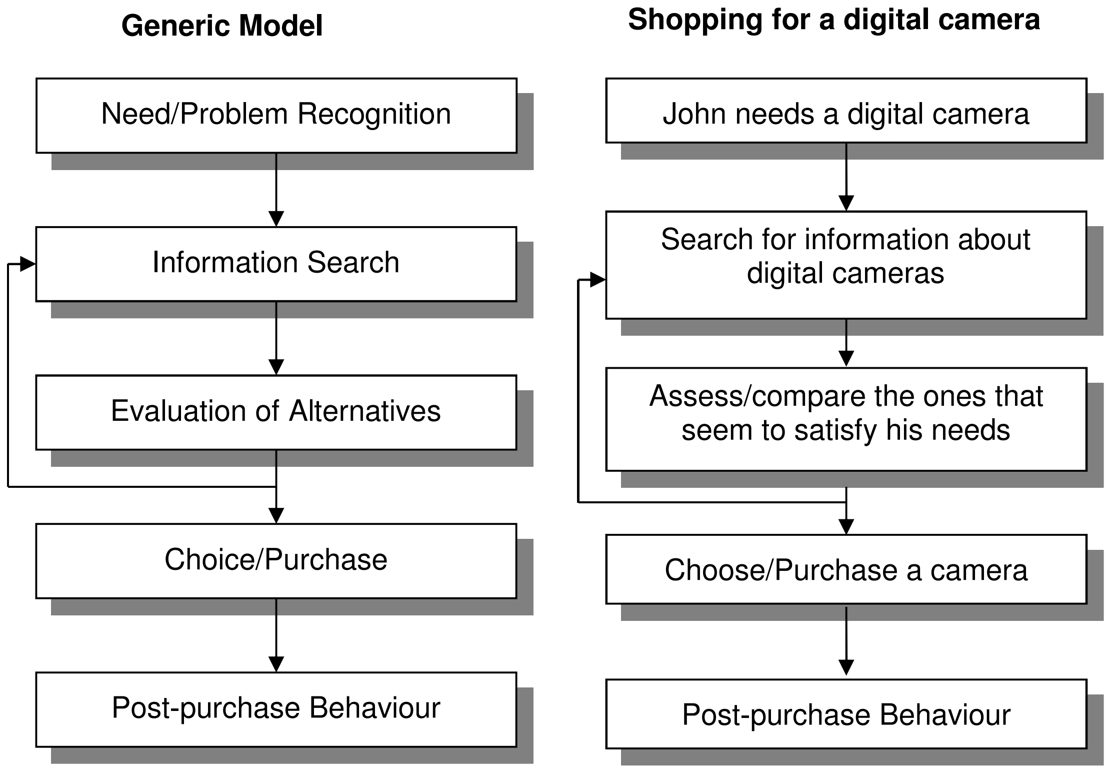


Figure 25 General decision-making process model and its instantiation to shopping for digital cameras

Information search, evaluation, and choice form the core of decision-making tasks in e-shopping. Until a choice is made, search and evaluation are the main processes involved. They do not necessarily occur only once; actually the opposite is more frequent, where search and evaluation alternate iteratively, until a decision is made; of course, the decision could be not to purchase the product.

7.4 Goals of the website

The website will support users choosing the best camera for their needs. It will describe each camera in terms of specifications, price and description of its main features. It will provide pictures of the cameras and pictures taken with the cameras and it will also support comparisons. In addition, the website will also allow the user to try out models of the cameras. Users interested in purchasing a digital camera, will come to the website to make a purchase decision.

The goal of interaction design is to define a set of interface objects and actions (and their screen representations) that enable a user to perform all defined tasks.

Consumer tasks: (*actions* (italics) and **objects** (boldface))

- *search* for **digital cameras**
- *select* a **camera**
- *examine* **camera description**
- *check* **technical specifications**
- *examine sample* **pictures** taken with this camera

- *examine* **reviews of a camera**
- *experience* **how the camera works**
- *compare* a **camera** with **other cameras**

From the objects identified, a domain model is derived (Figure 26).

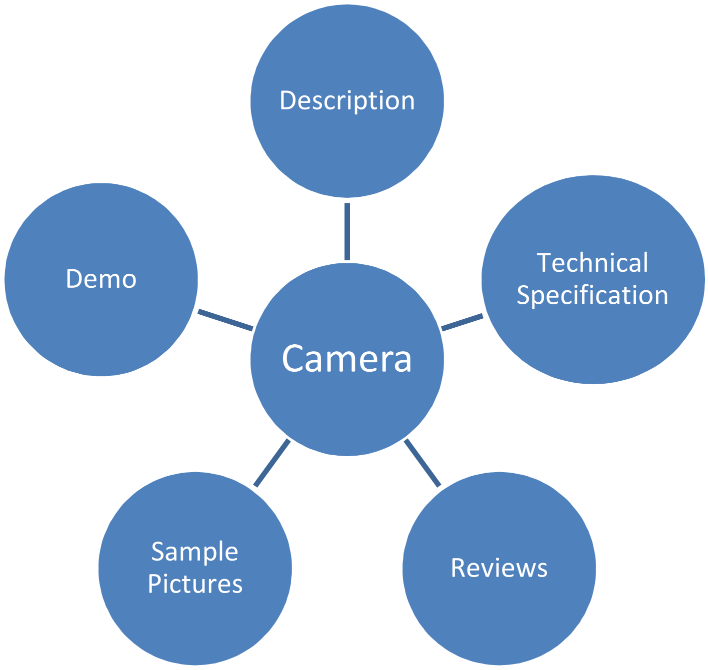


Figure 26 Domain model

7.5 Multimedia to support shopping tasks

Multimedia design follows the domain model. Here each information unit of the model is analysed in terms of multimedia requirements according to their information type. This is followed by a description of how each item of the model is designed. The additional requirement to support evaluation of alternatives is achieved by the design of comparison tools.

- **Demo: Experiencing cameras**

First of all, let us consider a consumer going to a physical store to shop for a digital camera. At some point, she will ideally have the possibility of touching a camera, turning it on, setting it up, and even taking a picture before making a purchase decision. Of course, this is not a requirement, especially if the consumer already has some direct experience with that particular camera. Furthermore, not all stores provide this facility. As explained in Chapter 5, the consumer does this in order to assess experience attributes. She is not only learning how a product performs, but actually how she performs using the product (Pine II and Gilmore 2011).

Following the information type ontology presented in Chapter 4 (Media Allocation and Combination, section 4.2.2.1), the camera demo can be characterised as:

- Abstraction from the real world: **physical**
- Change in time: **dynamic**

- Content: **discrete actions** (e.g., turning the camera on, taking a picture) and **procedures** (e.g. setting up the camera, reviewing a picture)

It is known that physical, concrete information is more easily and completely represented by non-linguistic media (see Chapter 4). In terms of change in time, trying out a camera involves a combination of dynamic and static information types. For instance, setting up the camera and taking a picture are examples of dynamic information types. Static information types, such as structural description of the components (e.g., lens, shutter, viewfinder), also play an important part in learning how to operate a camera. However, the basic characteristics of the camera demonstration are dynamic, since procedures and actions are more relevant for this task.

Referring to the criteria presented in Chapter 4, the media types that can be considered to represent the camera demo are animation, video, a combination of static pictures and text, or virtual reality combined with haptic interaction.

Operating an unfamiliar digital camera for the first time can be considered a relatively complex activity. In terms of naturalness, the degree of correspondence between the representation and the real world that is portrayed has a strong influence on how users' tasks will be carried out (Heller and Martin 1995). This is easier to think about in a store, in which a consumer is considering two cameras: one that has a demonstration model that can be inspected; and the other that has no demo model, only a brochure with pictures and text showing its functions. In this case the experience attributes can only be assessed for the one with the demo. Because the physical product is not present in an electronic shopping environment, a representation that is realistic enough for the user to assess the basic workings of the camera, the positioning of the controls and the facilities provided, should improve the consumer's confidence in a purchase decision.

A question remains: what degree of fidelity is necessary for the representation to have high degrees of naturalness and believability? One option for a representation, in this case, would be to have a video of the real camera, where someone would operate the camera showing its features. Whilst this would provide a high level of fidelity, it would not support the task of behavioural inspection. The video would only be able to support visual assessment, where the consumer does not influence the course of events. The same would happen with a combination of pictures and text.

The exploration feature emphasises that, in order to reduce uncertainty and increase understanding, users should be allowed to explore information in a guided manner (Carroll 1998). This allows the users to discover, by themselves, the workings of the camera; they learn best when they are actively involved, working on real tasks.

The use of interactive animations with added text was selected by this researcher for showing the workings of the cameras. Despite offering a more realistic interaction, virtual reality with haptic interaction was rejected since a simpler representation is capable of supporting the users' tasks. In other words, the task does not require the increased complexity of virtual reality interaction. In addition, it does not make a significant contribution in supporting the users' tasks.

The decision between a passive or an interactive animation is supported by the fact that the activity of trying out a camera is essentially interactive. Moreover, information overload can occur when the presentation of the workings of the camera is performed without interaction, as it is very difficult to integrate information.

The information is structured into sequences that naturally map the information domain. For example, three main sequences can be identified when trying out a digital camera: setting up the camera, taking a picture, and reviewing the picture (Figure 27).

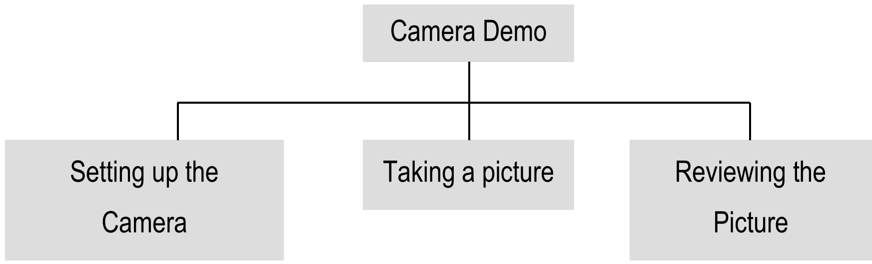


Figure 27 Basic structure of a camera demonstration

The basic requirement for a camera demonstration is to provide consumers with the ability to experience a product that is not physically present. As direct experience is not possible, multimedia experience is then implemented, as proposed in Chapter 5.

A semi-realistic model of a camera is then used to guide the user on the usage of the main features of the camera. The model that represents the camera has both physical and functional fidelity levels, appropriate for the tasks involved. The user is invited to explore the camera, following the pattern shown in Figure 27 and to learn how to setup the camera, how to take a picture and how to review the picture. The user interacts directly with the camera model, performing the task in a similar way that he/she would with the real camera.

As already mentioned, it is essential to give the user control over the pace of information delivery. Otherwise an uncontrollable flow of information could lead to information overload. Using the sequences shown in Figure 27, information is structured with natural breaks accordingly (Sutcliffe and Faraday 1994; Schar, Zuberbühler et al. 2000).

The exploration provided by the IMPE also engages the user more in self-directed activity. Providing the user with opportunities to act, to the greatest possible extent under his/her control, improves learning (Carroll 1998). Discovery learning is an essential element in the theoretical foundation of minimalist design philosophy. Minimalism assumes that learners should be active, working on real or realistic tasks as they learn and part of the reason for this is that real tasks are highly motivating. Engaging in genuine activities during learning also better supports transfer to real situations, by bringing the learning situations and transfer situations into closer correspondence (Carroll 1998).

The demonstration shows the camera's controls, and highlights buttons/controls that can be selected at each step. For example, Figure 28 shows the steps involved to change exposure compensation, one of the many features of this camera. The user can see that this option is available, can select it, and can scroll the possible values to be set. On the left of the camera, a brief explanation of the feature is shown, together with instructions for alternative actions. The instructions are designed to provide appropriate cueing to direct the user's attention to a certain part of the animation and to encourage him/her to explore.

If the user is done with the setup, he/she can use the mode dial (big button on the bottom right) to change the mode to "capture", in order to take a picture (that is exactly what would be needed to be done with a real camera).

Figure 28 Setting up the camera: changing exposure compensation

In order to take a picture (Figure 29), the user is presented with a realistic view, with the camera positioned as if he/she was holding it, and pointing it at the view. By pressing the indicated button, he/she can preview the picture in the LCD. If he/she wants, it is possible to adjust the zoom, and the brightness of the LCD display. When he/she is satisfied, the picture is taken by pressing the shutter.

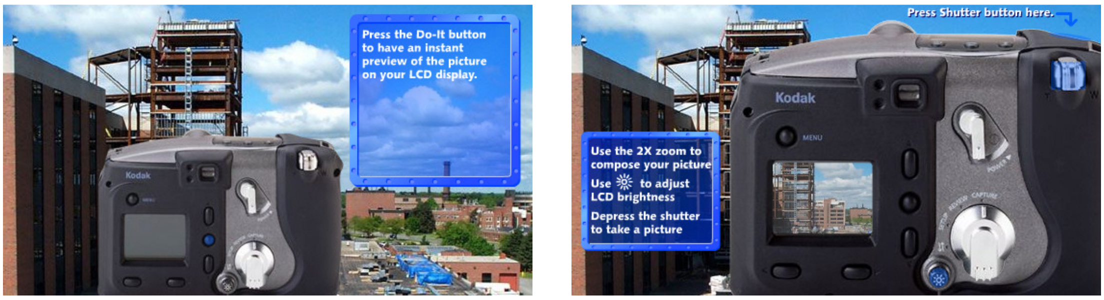


Figure 29 Taking a picture: preview, zoom, brightness control, and shutter

The combination of naturalness with exploration features provides a very realistic sense of using the camera. The realistic model reproduces all the components of the real camera, and each behaviour is activated by some action (e.g. a mouse click in the camera shutter). So on top of the visual inspection, it is possible to perform behavioural inspection, where direct experience with a real camera is simulated. To increase the realness of the interaction audio is also used, to simulate the sound of pressing the real buttons. For instance, the pressing of the shutter is accompanied by a characteristic sound encountered in photographic cameras. Thus, it is expected that the acoustic feedback added to the visual feedback will produce an experience that is closer to real life.

The interactive animations help the user to establish the causal connection between his/her actions and the behaviour of the camera. The models are not freely interactive, i.e. the user has to follow some instructions – the reason for this is so that only the most salient features are focused upon and no peripheral functions of the cameras are demonstrated. This helps the user attend to the most relevant details, and reduces the complexity of the interaction with a new piece of equipment. Otherwise, the number of possible actions that could take place would be enormous and the user could have problems in making sense of the relevant features, simply because there is too much to attend to and this could very easily overload the user. Of course, there is always the question of what exactly is relevant to the user, which features are important and which are not. Features will generally be considered more important when they are diagnostic of causal function and part of a larger framework (Choplin et al 2001). For this reason, the functions available to the user at a certain point should be highlighted, so that he/she knows the possible paths. For example, after setting up the camera and adjusting shutter aperture and speed, the user is invited to take a picture and, at this point, he/she can press the shutter or adjust the zoom and all other controls are then unavailable. This type of exploration follows the minimalist guided exploration model (Caroll 1990; 1998).

Since the product is new to the consumer, but he wants to have an idea of how it works or of what he can do with it, genuine activity must be made available to him. Because of that there is a need to scaffold, stage, and structure this activity to ensure that it is tractable and understandable (Pine II and Gilmore 2011). The purpose of the consumer here is not to learn in detail how to use the product, but to get a feeling of the possibilities offered by it, and see the basic functioning (Meij and Carroll 1998). The present design of the cameras' demos provides users with an immediate opportunity to act (Meij and Carroll 1998). By encouraging and supporting exploration, "people are more engaged by self-directed activity; they prefer it and learn more from it" (Meij and Carroll 1998, p. 23).

- **Description: pictures of the cameras**

In the absence of the physical product, consumers need to see it to help them make a complex purchase decision. The physical, static information describing the object camera can be represented by an image or set of images. As the main task here is to have a clear idea of what the camera looks like, a realistic representation is needed and since the information itself is concrete, static pictures would seem to be an adequate representation. Moreover, spatial information is generally considered difficult to convey and to interpret, such as the size of a camera. In Figure 30, a hand holds the DC3800 camera to help communicate the size of the camera[54]. Figure 30 also shows the available pictures for the DC3400 with the back of the camera being shown.

Figure 30 Pictures of the camera (left: DC3800; right: DC3400)

The static, realistic pictures of the cameras support an important type of product inspection – visual inspection – where the consumer inspects the visual attributes of a product, seeing it from different angles. Quality of information representation of the product is important, otherwise negative attitudes will be formed about the product (Jiang, Wang et al. 2005). Another way to support the visual inspection task is to provide a realistic or semi-realistic model of the camera that can be turned and examined from different angles. This model can be a 3D model (Li, Daugherty et al. 2002) or one of 360 degrees. The latter is provided in the present prototype as a redundant complement to the static pictures and to the cameras' demonstrations. Figure 31 shows a camera in

[54] The precise size is given in the table of the specifications.

a 360-degree view: the user can turn the camera, and the semi-realistic model will turn accordingly (the figure shows five intermediate pictures of the interaction – the user sees only one model). Increase in redundancy will not by itself increase the amount of information transmitted; the goal is to reduce the amount of residual uncertainty.

Pictures of the cameras are also used in combination with text indicating the name of a camera. This media combination helps the customers identify the camera as the name alone does not carry much meaning.

Figure 31 A camera in 360-degree view

- **Sample pictures taken**

In order to assess a digital camera's quality, seeing a picture captured by the camera supports consumer evaluation. In a study about changes in consumer behaviour, Pine II and Gilmore (2011) observed that learning how a product performs is not enough anymore, because consumers want to see how they themselves perform using the product. As the physical product is not present in an e-commerce interaction, in order to reduce consumer uncertainty, it is then important to show results obtained using it.

The main purpose of seeing pictures taken with a digital camera is to evaluate the quality of the pictures it is able to produce. However, several factors can affect the quality of a photograph, so the challenge is to control the pictures taken. The solution adopted here is to have all the cameras take the same two pictures, one in low light conditions, indoors (the musicians) and the other outdoors (the house) (Figure 32). In this case, the media used is exactly the one produced by the cameras: non-edited static pictures, allowing consumers to have a realistic and believable way of seeing how good the cameras can be.

Figure 32 Pictures taken with one camera

- **Description of cameras, Reviews and Technical Specification**

The description of a camera can be classified as static and physical information type combined with descriptive information. When a camera is selected, its description is the first information a consumer has access to. It consists of the name and a small picture of the camera, a bullet list with its main features, and the beginning of the reviews for this camera (Figure 33).

The description of the main features and the reviews[55] support the analysis that is involved when making a purchase decision. As already seen in Chapter 4, descriptive information is better communicated by linguistic media, i.e. text (static) or speech (dynamic).

Text is chosen over speech, as text offers control over the inspection that is not supported by speech. For instance, while reading a review the user may pause, check some of the specifications, and then go back to reviews, perhaps re-reading the same passage, or jumping to another aspect. A small picture is combined with the text to identify the camera, giving the user a first idea of what it looks like.

The specifications of the camera can be classified as descriptive and static information type. Describing attributes like: size, price, zoom, and resolution, is better accomplished by text, because these need to be inspected, probably several times, before the consumer makes a decision. To represent the values of each feature, a table is used (Figure 34).

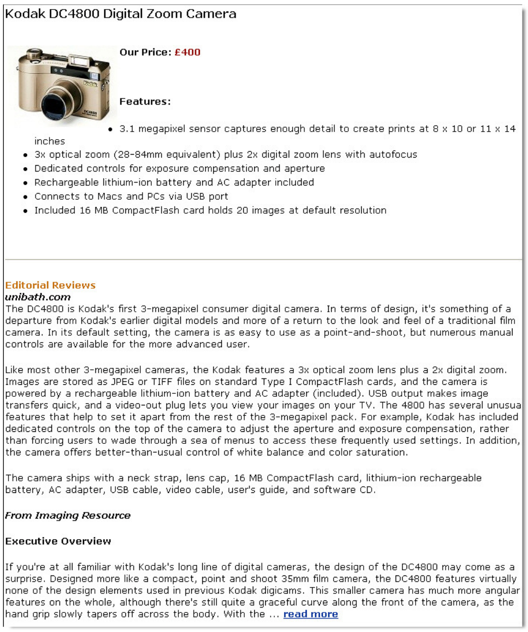


Figure 33 Basic description of the camera

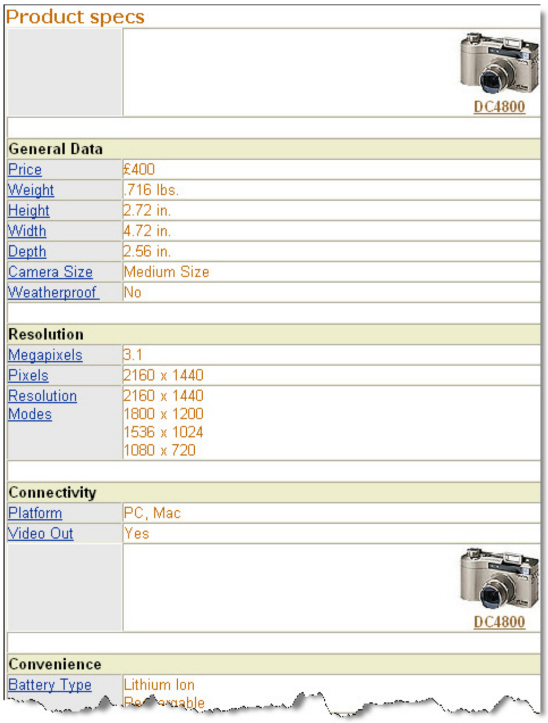


Figure 34 Technical specifications

Consumers with low product class knowledge could potentially have difficulties interpreting and comparing the attribute values for each alternative. To alleviate this problem it is important to provide information describing each attribute, which is achieved by selecting the attribute in question and displaying its meaning (Figure 35).

[55] The reviews used in this prototype are only editorial, coming from specialised websites. Although reviews from other consumers are considered very important to reduce perceived risk, they were not used here so as to reduce the complexity of the decision making process.

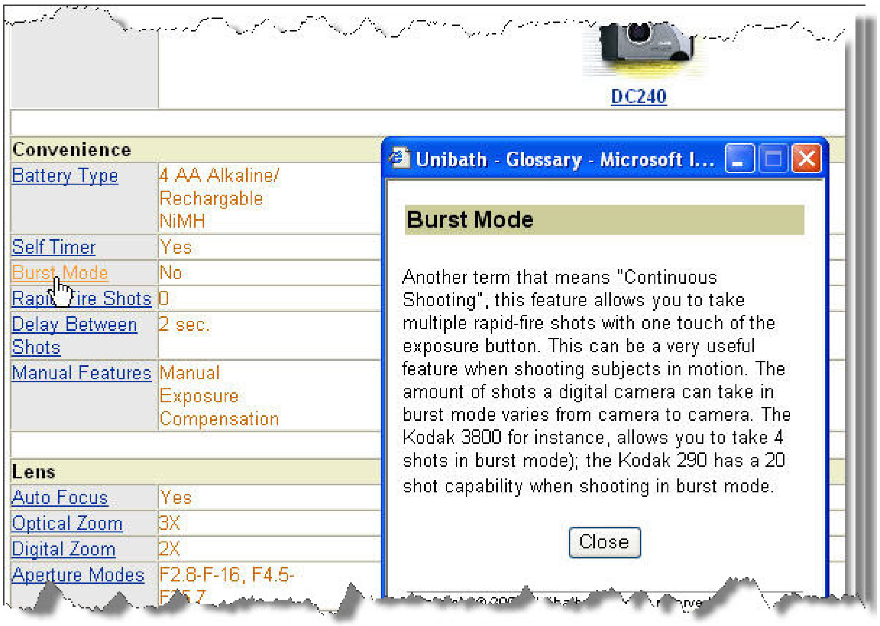


Figure 35 Explaining an attribute (Burst Mode)

- **Comparisons**

Facilities for comparison shopping are one of the most cited advantages of e-shopping. Enabling consumers to compare products helps them identify the product that best meets their needs.

There are many ways to support comparisons, depending on the type of attributes a product has. For search attributes, tables listing the attributes and their values are used in an alternative-by-attribute manner. In the case of digital cameras, the attributes are exactly the same ones used for showing the specifications of an individual camera. To maintain consistency, the attributes themselves can also be selected for further clarification of their meaning/relevance. For example, Figure 36 shows a comparison between the DC3800 (shown in the first column) and all other cameras.

Kodak DC3800 Digital Zoom Camera

Our Price: £247

Comparison of Specs: All Cameras

	DC3800	EZ200	DC3200	DC215	DC215 Millenium	DC3400	DC240	DC280	DC5000	DC4800	DC290
General Data											
Price	£247	£75	£117	£200	£233	£266	£294	£300	£385	£400	£410
Weight	.36 lbs.	.2 lbs.	.475 lbs.	.66 lbs.	.66 lbs.	.75 lbs.	.7 lbs.	.75 lbs.	1.011 lbs.	.716 lbs.	1.2 lbs.
Height	1.3 in.	2.7 in.	3.1 in.	2.7 in.	2.7 in.	3 in.	3 in.	3 in.	3.267 in.	2.72 in.	4.2 in.
Width	3.7 in.	3.6 in.	4.45 in.	4.5 in.	4.5 in.	5.2 in.	5.2 in.	5.2 in.	5.51 in.	4.72 in.	4.6 in.
Depth	2.4 in.	1.4 in.	2.1 in.	1.7 in.	1.7 in.	2.1 in.	2 in.	2 in.	3.503 in.	2.56 in.	2.2 in.
Camera Size	Pocket Size	Pocket Size	Pocket Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	SLR Size
Weatherproof	No	No	No	No	No	No	No	No	Yes	No	No
Resolution											
Megapixels	2.1	0.3	1.0	1.0	1.0	2.0	1.2	2.0	2.0	3.1	2.1
Pixels	1792 x 1200	640 x 480	1152 x 864	1152 x 864	1152 x 864	1760 x 1168	1280 x 960	1760 x 1168	1760 x 1168	2160 x 1440	1792 x 1200
Resolution Modes	1792 x 1200 896 x 600	640 x 480 320 x 240	1152 x 864 575 x 435	1152 x 864 640 x 480	1152 x 864 640 x 480	1760 x 1168 896 x 592	Best Better Good	1760 x 1168 896 x 592	1760 x 1168 896 x 592	2160 x 1440 1800 x 1200 1536 x 1024 1080 x 720	2240 x 1500 (interpolated) 1792 x 1200 1440 x 960 720 x 280
Connectivity											
Platform	PC, Mac	PC Only	PC Only	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac
Video Out	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	DC3800	EZ200	DC3200	DC215	DC215 Millenium	DC3400	DC240	DC280	DC5000	DC4800	DC290
Convenience											
Battery Type	2 AA Alkaline	2 AAA Alkaline	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline	4 AA	Lithium Ion Rechargable	4 AA Alkaline/ Rechargable NiMH
Self Timer	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Burst Mod	Ye	es	[illegible]	No	No	No	[illegible]	[illegible]	No	Yes	Y

Figure 36 Comparing specifications of the DC3800 with all other cameras

Research done in consumer behaviour shows that consumers will restructure information if it enables them to facilitate choice (Coupey 1994). It is difficult to predict the way users will process information, thus, giving control to users will allow them to choose their own way to compare the attributes. In order to support that, the current design makes it possible to compare cameras that are similar in price, resolution or size. For example, Figure 37 shows the DC3800 camera being compared with cameras that have similar size (in this case, they are all pocket size cameras).

Kodak DC3800 Digital Zoom Camera

Our Price: £247

Comparison of Specs: Similar Size

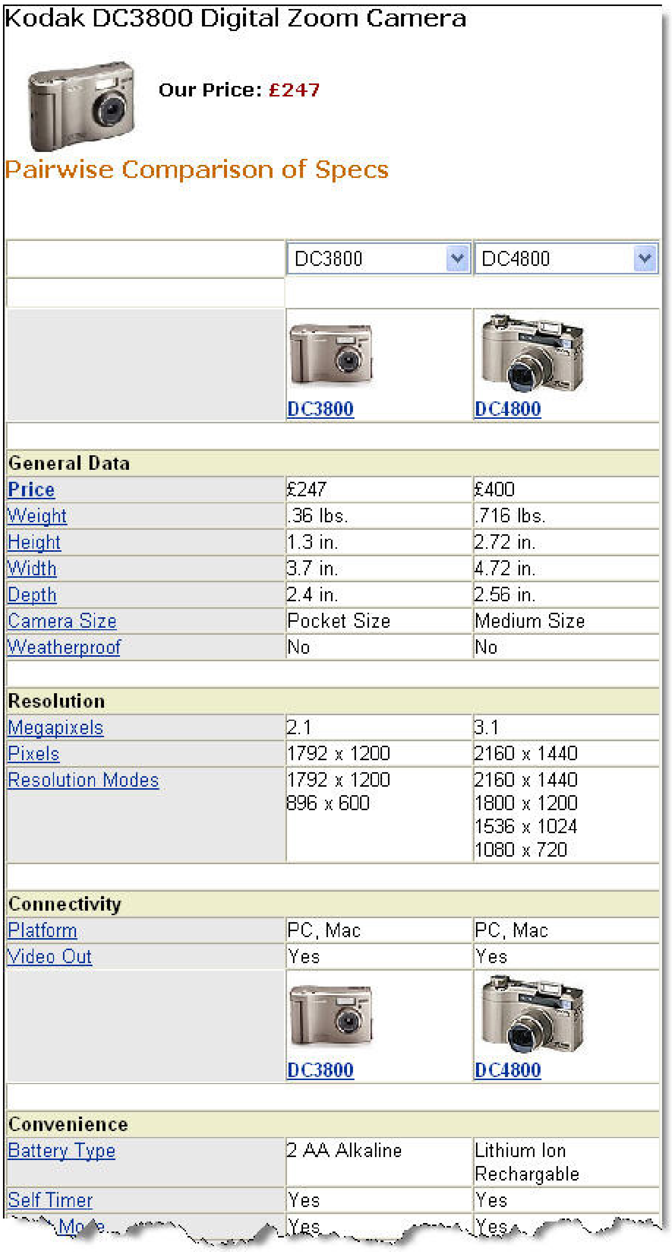
	DC3800	EZ200	DC3200
General Data			
Price	£247	£75	£117
Weight	.36 lbs.	.2 lbs.	.475 lbs.
Height	1.3 in.	2.7 in.	3.1 in.
Width	3.7 in.	3.6 in.	4.45 in.
Depth	2.4 in.	1.4 in.	2.1 in.
Camera Size	Pocket Size	Pocket Size	Pocket Size
Weatherproof	No	No	No
Resolution			
Megapixels	2.1	0.3	1.0
Pixels	1792 x 1200	640 x 480	1152 x 864
Resolution Modes	1792 x 1200 896 x 600	640 x 480 320 x 240	1152 x 864 575 x 435
Connectivity			
Platform	PC, Mac	PC Only	PC Only
Video Out	Yes	No	Yes
	DC3800	EZ200	DC3200
Convenience			
Battery Type	2 AA Alkaline	2 AAA Alkaline	4 AA Alkaline
Self Timer	Yes	Yes	N/A

Figure 37 Comparing the DC3800 with cameras similar in size

Comparison tasks allow consumers to use decision rules, either compensatory or non-compensatory, with regard to the criteria used to evaluate alternatives and attributes. Because the rules are specific for each decision making act, it is best to provide comparison tools that are flexible and under user's control.

The ability to compare cameras also contributes to a reduction in the perception of risk (Spiekermann and Parachiv 2002; Gefen, Rao et al. 2003). For instance, the consumer can choose any two cameras and compare them using different criteria. First, it is possible to compare their specifications (Figure 38). Another way to make comparisons is to see pictures taken with the cameras side-by-side (Figure 39). The pictures are the same ones used to show pictures taken by each individual camera. However, being able to see them side-by-side offers a new facility of comparison, where there is no need for the consumer to rely on his/her working memory. This type of comparison tool is designed to support a better evaluation of the alternatives, as side-by-side comparisons can help consumers to make better informed decisions. Another design decision is to make it possible to change cameras easily so as to allow the user to compare pictures taken with other cameras as well. A third way to make comparisons is by selecting two cameras and interacting with them at the same time, side-by-side. Figure 40 shows a pairwise comparison of camera demonstrations for the DC3800 and the DC4800. The user is able to interact with them in parallel, comparing the facilities offered by them, and see how easy they are to operate.

The criteria used for pairwise comparisons, namely: specifications, picture quality, and demos, provide decision-relevant information that supports the decision-making process.



Kodak DC3800 Digital Zoom Camera

Our Price: £247

Pairwise Comparison of Specs

	DC3800	DC4800
	DC3800	DC4800
General Data		
Price	£247	£400
Weight	.36 lbs.	.716 lbs.
Height	1.3 in.	2.72 in.
Width	3.7 in.	4.72 in.
Depth	2.4 in.	2.56 in.
Camera Size	Pocket Size	Medium Size
Weatherproof	No	No
Resolution		
Megapixels	2.1	3.1
Pixels	1792 x 1200	2160 x 1440
Resolution Modes	1792 x 1200 896 x 600	2160 x 1440 1800 x 1200 1536 x 1024 1080 x 720
Connectivity		
Platform	PC, Mac	PC, Mac
Video Out	Yes	Yes
	DC3800	DC4800
Convenience		
Battery Type	2 AA Alkaline	Lithium Ion Rechargable
Self Timer	Yes	Yes
[illegible]	Yes	Yes

Figure 38 Comparing the specifications of two cameras

Figure 39 Comparison of pictures taken with the cameras

Figure 40 Comparing demonstrations: DC3800 x DC4800

7.6 Site structure and navigation

The main goal of a website structure is to make it easy for users to comprehend the information presented (Rosenfeld and Morville 2006). The organisational scheme may reflect different functionalities, such as: task characteristics, domain knowledge relationships, or logical ordering and connections, in order to accommodate users' needs. In the present design, the structure is task oriented, as there is a limited number of frequently used actions (Heller, Martin et al. 2001). The information structure reflects the domain model (Table 13); the way it is implemented is shown in Figure 41.

Table 13 From domain model to site structure

Domain model	Website structure
Description	Buying information
	More pictures of the camera
Technical specifications	Product specifications
Reviews	Editorial reviews
Demonstration	How it works
Sample pictures taken	Pictures taken with this camera

Figure 41 Structure of the website

Because the basic unit of the website is a camera, each camera is presented with a banner and its picture, which helps the user identify the current camera and also orientate him/herself (Figure 42). The visual organisation reinforces the website structure and builds context for the user.

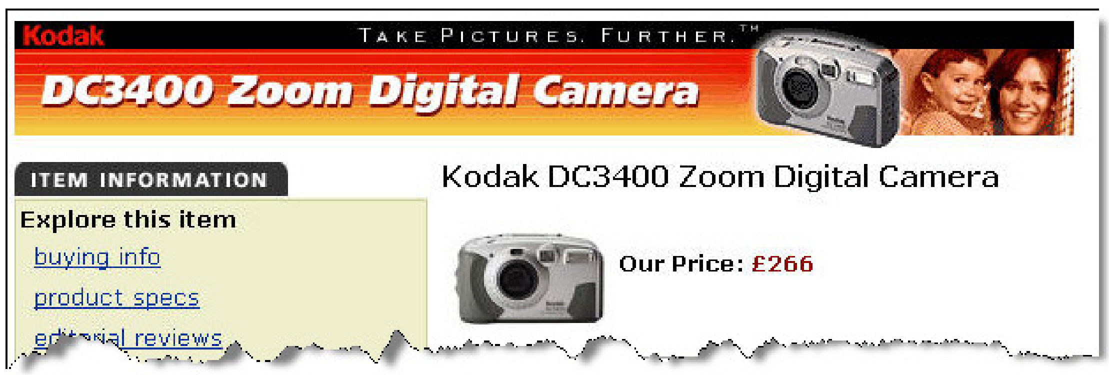


Figure 42 Banner and picture of a camera

The navigation bar that appears on the left hand side of the interface is divided in two groups (Figure 43): 'Item Information' and 'Cameras'. They are consistently presented in the same manner for every camera representation: they appear in a consistent location, have a consistent appearance, and use a consistent labelling system, no matter where the user is on the website (McCracken and Wolfe 2004).

From Figure 43, it can be seen that related items are grouped together, with their alignment used to clarify meaning. From 'Item Information', the user has access to information about that particular camera organised around the tasks: 'Explore this item', 'Comparison of Specs' and 'Pairwise Comparison'. The 'Explore this item' sub-menu corresponds to the basic structure of each camera, as shown in Figure 36. 'Comparison of Specs' compares the current camera 'with all other cameras' (already shown in Figure 36) or only 'with cameras similar in price, resolution or size' (already shown in Figure 37). 'Pairwise comparison' compares the current camera with another one selected by the user. The user then chooses the criteria of comparison: specifications (Figure 38), picture quality (Figure 39), or how it works (Figure 40). The pairwise comparison facility also allows the user to easily change the cameras he/she wishes to compare.

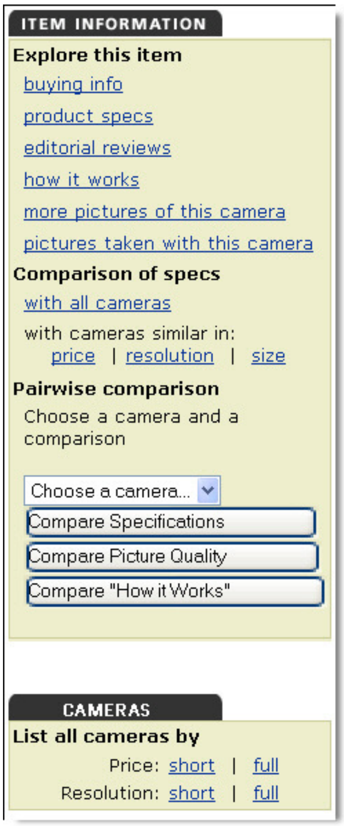
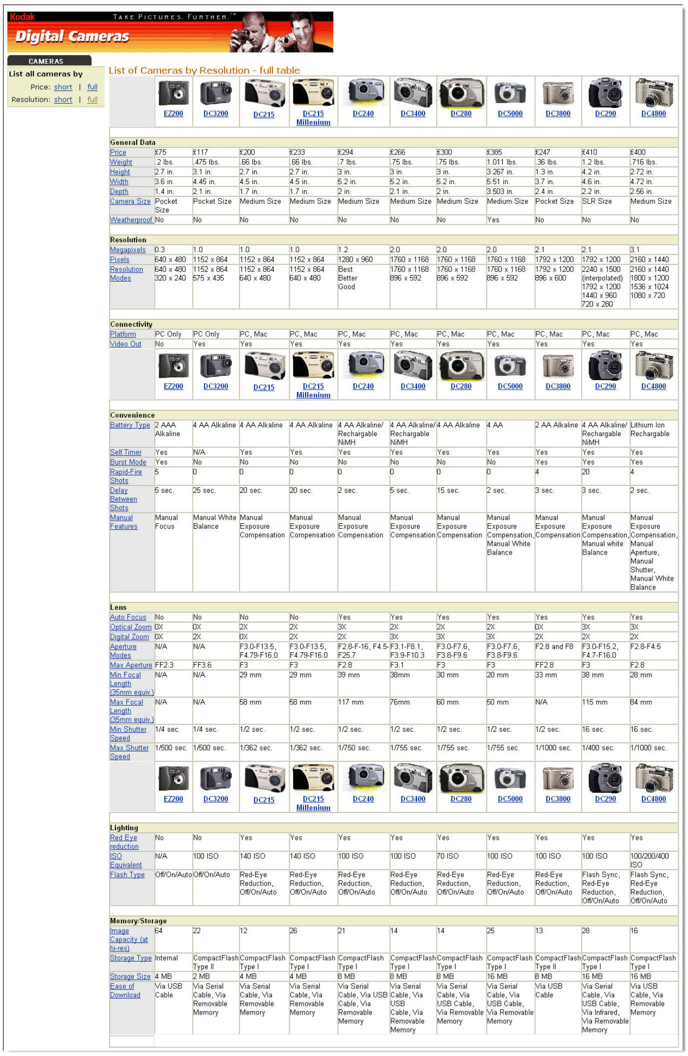


Figure 43 Task-oriented menu

From the 'Cameras' sub-menu, it is possible to list all the cameras sorted by 'Price' or 'Resolution'. This results in a table of all the cameras that can be viewed in a short (Figure 44) or a full display (Figure 45). From these tables the user can select either another table, or a particular camera, thus providing them with control and easy access to any part of the website.

	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC280	DC5000	DC4800	DC290
General Data											
Price	£75	£117	£200	£233	£247	£266	£294	£300	£385	£400	£410
Camera Size	Pocket Size	Pocket Size	Medium Size	Medium Size	Pocket Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	SLR Size
Resolution											
Megapixels	0.3	1.0	1.0	1.0	2.1	2.0	1.2	2.0	2.0	3.1	2.1
Pixels	640 x 480	1152 x 864	1152 x 864	1152 x 864	1792 x 1200	1760 x 1168	1280 x 960	1760 x 1168	1760 x 1168	2160 x 1440	1792 x 1200
Lens											
Optical Zoom	0X	0X	2X	2X	0X	2X	3X	2X	2X	3X	3X
Digital Zoom	0X	2X	0X	2X	2X	3X	2X	3X	3X	2X	2X
Memory/Storage											
Image Capacity (at hi-res)	64	22	12	26	13	14	21	14	25	16	28
Storage Size	4 MB	2 MB	4 MB	4 MB	8 MB	8 MB	8 MB	8 MB	16 MB	16 MB	16 MB

Figure 44 List of cameras by price - short table



	EZ200	DC3200	DC215	DC215 Millenium	DC240	DC3400	DC280	DC5000	DC3800	DC290	DC4800
General Data											
Price	£75	£117	£200	£233	£294	£266	£300	£385	£247	£410	£400
Weight	.2 lbs.	.475 lbs.	.66 lbs.	.66 lbs.	.7 lbs.	.75 lbs.	.75 lbs.	1.011 lbs.	.36 lbs.	1.2 lbs.	.716 lbs.
Height	2.7 in.	3.1 in.	2.7 in.	2.7 in.	3 in.	3 in.	3 in.	3.267 in.	1.3 in.	4.2 in.	2.72 in.
Width	3.6 in.	4.45 in.	4.5 in.	4.5 in.	5.2 in.	5.2 in.	5.2 in.	5.51 in.	3.7 in.	4.6 in.	4.72 in.
Depth	1.4 in.	2.1 in.	1.7 in.	1.7 in.	2 in.	2.1 in.	2 in.	3.503 in.	2.4 in.	2.2 in.	2.56 in.
Camera Size	Pocket Size	Pocket Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	Pocket Size	SLR Size	Medium Size
Weatherproof	No	No	No	No	No	No	No	Yes	No	No	No
Resolution											
Megapixels	0.3	1.0	1.0	1.0	1.2	2.0	2.0	2.0	2.1	2.1	3.1
Pixels	640 x 480	1152 x 864	1152 x 864	1152 x 864	1280 x 960	1760 x 1168	1760 x 1168	1760 x 1168	1792 x 1200	1792 x 1200	2160 x 1440
Resolution Modes	640 x 480 320 x 240	1152 x 864 575 x 435	1152 x 864 640 x 480	1152 x 864 640 x 480	Best Better Good	1760 x 1168 896 x 592	1760 x 1168 896 x 592	1760 x 1168 896 x 592	1792 x 1200 896 x 600	2240 x 1500 (interpolated) 1792 x 1200 1440 x 960 720 x 280	2160 x 1440 1800 x 1200 1536 x 1024 1080 x 720
Connectivity											
Platform	PC Only	PC Only	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac
Video Out	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	EZ200	DC3200	DC215	DC215 Millenium	DC240	DC3400	DC280	DC5000	DC3800	DC290	DC4800
Convenience											
Battery Type	2 AAA Alkaline	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline	4 AA	2 AA Alkaline	4 AA Alkaline/ Rechargable NiMH	Lithium Ion Rechargable
Self Timer	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Burst Mode	Yes	No	No	No	No	No	No	No	Yes	Yes	Yes
Rapid-Fire Shots	5	0	0	0	0	0	0	0	4	20	4
Delay Between Shots	5 sec.	25 sec.	20 sec.	20 sec.	2 sec.	5 sec.	15 sec.	2 sec.	3 sec.	3 sec.	2 sec.
Manual Features	Manual Focus	Manual White Balance	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation, Manual White Balance	Manual Exposure Compensation	Manual Exposure Compensation, Manual white Balance	Manual Exposure Compensation, Manual Aperture, Manual Shutter, Manual White Balance
Lens											
Auto Focus	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Optical Zoom	0X	0X	2X	2X	3X	2X	2X	2X	0X	3X	3X
Digital Zoom	0X	2X	0X	2X	2X	3X	3X	3X	2X	2X	2X
Aperture Modes	N/A	N/A	F3.0-F13.5, F4.79-F16.0	F3.0-F13.5, F4.79-F16.0	F2.8-F-16, F4.5-F25.7	F3.1-F8.1, F3.9-F10.3	F3.0-F7.6, F3.8-F9.6	F3.0-F7.6, F3.8-F9.6	F2.8 and F8	F3.0-F15.2, F4.7-F16.0	F2.8-F4.5
Max Aperture	FF2.3	FF3.6	F3	F3	F2.8	F3.1	F3	F3	FF2.8	F3	F2.8
Min Focal Length (35mm equiv.)	N/A	N/A	29 mm	29 mm	39 mm	38mm	30 mm	20 mm	33 mm	38 mm	28 mm
Max Focal Length (35mm equiv.)	N/A	N/A	58 mm	58 mm	117 mm	76mm	60 mm	50 mm	N/A	115 mm	84 mm
Min Shutter Speed	1/4 sec.	1/4 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	16 sec.	16 sec.
Max Shutter Speed	1/500 sec.	1/500 sec.	1/362 sec.	1/362 sec.	1/750 sec.	1/755 sec.	1/755 sec.	1/755 sec.	1/1000 sec.	1/400 sec.	1/1000 sec.
	EZ200	DC3200	DC215	DC215 Millenium	DC240	DC3400	DC280	DC5000	DC3800	DC290	DC4800
Lighting											
Red Eye reduction	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ISO Equivalent	N/A	100 ISO	140 ISO	140 ISO	100 ISO	100 ISO	70 ISO	100 ISO	100 ISO	100 ISO	100/200/400 ISO
Flash Type	Off/On/Auto	Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Flash Sync, Red-Eye Reduction, Off/On/Auto	Flash Sync, Red-Eye Reduction, Off/On/Auto
Memory/Storage											
Image Capacity (at hi-res)	64	22	12	26	21	14	14	25	13	28	16
Storage Type	Internal	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I
Storage Size	4 MB	2 MB	4 MB	4 MB	8 MB	8 MB	8 MB	16 MB	8 MB	16 MB	16 MB
Ease of Download	Via USB Cable	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via USB Cable	Via Serial Cable, Via USB Cable, Via Infrared, Via Removable Memory	Via USB Cable, Via Removable Memory

Figure 45 List of cameras by resolution - full table

The navigation reflects the structure of the content, which is based on users' tasks. It enables them to accomplish their goals using the strategies they prefer. As the prototype website is relatively small, there is no need for other navigation tools, such as: breadcrumbs or site maps. Furthermore, the back and forward buttons on the browser can also be used, which adds to the designed navigational facilities.

Because one of the purposes of the prototype is to test hypotheses, familiarity with the layout of the designed website was a major requirement to be addressed. Hence, the visual appearance is based on the popular Amazon.com website, with the intention of reducing problems with familiarity. The users of the website can be characterised as being competent performers in terms of the web in general, and advanced beginners for the particular website (Hackos and Redish 1998). The cameras and the information about them are all real, and were taken from different websites (Kodak.com, imaging-resource.com and Amazon.com).

7.7 Conclusions

The design and implementation of the e-shopping website selling digital cameras was done to satisfy two purposes:

- to apply the design criteria developed in Chapter 4 with design considerations of electronic-shopping presented in Chapter 5;
- to test hypotheses presented in Chapter 6.

The environment that has been built is an e-shopping website with multimedia experience for consumers to experience digital cameras when the physical product is not present. In order to support the shopping task of evaluating alternatives, comparison tools of search and experience attributes have been designed and implemented.

In terms of the application of the design criteria, design features were applied for the choices made: media allocation and combination, naturalness/realness, exploration, quality of information representation, redundancy and significant contribution of media.

On top of the specific multimedia features that were applied, the resulting website has been designed with several HCI principles and guidelines in mind, such as: comprehensibility, learnability, clarity, simplicity, efficiency, controllability, flexibility and consistency.

To be able to test hypotheses, different versions of the system need to be created, so that multimedia experience and/or comparison tools are not present. These different versions are described in the next chapter, together with the experimental design.

Chapter 8 Experimental Study[56]

8.1 Introduction

This chapter presents the experiment that tests the hypotheses described in Chapter 6. It starts with a critical analysis of experimental work previously carried out by other researchers. From it we conclude that there is a gap in electronic shopping behaviour research. Next, the independent variables MM and CT are presented in detail, followed by procedure, participants, dependent variables, and tasks. Complete results for each of the hypothesis are given. The chapter concludes with an analysis of the open-ended questions. Interpretation of the results is given in the subsequent chapter.

8.2 Previous empirical work

The central premises of this study were that well designed multimedia product experiences can simulate direct product experiences and that comparison tools support effectively and efficiently a complex decision-making process. These ideas have support in general consumer behaviour literature but have yet to be completely understood in electronic shopping environments. As will be seen in this section, some attempts have been made, but further assessment is required.

The basic issue of the present research has addressed is one that considers the role of multimedia in consumer - e-shopping interaction. Specifically, the focus is on the understanding of the effects multimedia produces in the decision-making process.

Currently, most of the experimental work on how consumers make purchase decisions online comes from marketing - advertising and consumer behaviour - which explains why there are so many studies interested in persuasion effect.

Most of the studies tend to use a survey method (e.g., (Choudhury and Karahann 2008)); for instance, out of 35 studies analysed by Li and Zhang (2002), 29 (83%) used a survey method. Although very useful to uncover antecedents and problems, surveys only tell part of the story, i.e., users opinions. They do not tell what users in fact do as they rely on respondents’ subjective memories. For example, based on a survey with 289 people, Lee, Kim et al. (2000) suggested that involvement with product has a strong link with transaction cost, and consequently with customer loyalty and satisfaction. Basically, the more the consumer is involved with the product, the more satisfied and loyal he is. However, this study was essentially descriptive; it cannot provide causal explanations of the relationship between consumers' satisfaction and actual performance.

Table 14 shows a summary of the following studies based on lab experiments and their findings in the area of e-shopping:

1. Klein (2003) described two experiments using only one product in each as stimulus: a wine and a face cream. The intention was to assess the effects of media richness and user control over judgements (beliefs, attitudes, persuasion). Media richness was manipulated by presenting the product through video or through pictures. User control was manipulated presenting the product sequentially or in any order chosen by the user. Media richness and user control showed some effects on persuasion and attitudes, but no effects on learning. However, in Klein’s study, there was no product choice and no decision-making, two fundamental activities of shopping. It was a study on advertising – and the ultimate goal of advertising is to persuade

[56] Some parts of this chapter appeared in (Nemetz and Johnson 2006)

potential customers to make a favourable decision when they have to buy a product in a category (Kim and Biocca 1997). The research paradigm followed by Klein was based on a preference model as opposed to a choice model. A preference model is used to study consumer preference formation towards a particular product, whereas a choice model tries to predict consumer behaviour when faced with a set of alternatives (Lowengart and Tractinsky 2001). Furthermore, the media rich condition was based on the use of what Klein calls “interactive” video, where interactive means the possibility of pausing the video.

2. The study by Haubl and Figueroa (2002) used only 3 webpages. Each page described one PDA (personal digital assistant) showing a 3D-model of the product. Only visual inspection was offered; it was not possible to interact with the model. The pages also contained product specifications. Their results were reported as preliminary, and there was no mention of satisfaction with the decisions. Similar to the work of Klein (2003), they took the merchant's point of view, i.e., how to use 3D models to sell more. They found that products presented using 3D-models were chosen more often than products presented with 2D-pictures. One problem with this experiment is that, based on the description given for the website, the information in each of the conditions was not equivalent[57]. For instance, for the PDAs described with 3D-models, it was possible to see them from different angles, which yields a better feeling of its shape and weight. In contrast, in the 2D condition only one picture was offered. Therefore, it could very well be possible that the reason for preference was related to the amount of information, and not the 3D-model itself.

3. Jiang and Benbasat (2007) used a preference model to measure the effects of vividness and interactivity. The authors presented two products, a wrist watch and a PDA, manipulating the independent variables in four conditions: static images (low vividness, low interactivity), video with and without narration (high vividness, low interactivity), and virtual product experience (high vividness, high interactivity). Participants were assigned to one of the four conditions, and were asked to examine the two products in order to decide whether they would complete a purchase or not. Participants then completed a questionnaire that measured perceived diagnosticity, compatibility with in-store shopping, shopping enjoyment, attitudes towards products, attitudes towards shopping at a website, intention to purchase and intention to return to the website in the future. Authors reported the same effects for both products: they found positive significant effects in all measurements for both vividness and interactivity. The measurements were all based on questionnaires, and no observation was made to extract how the participants behaved. Also, the study setting was not based on choice, so they could not show the results in a more realistic choice model. Finally due to the conditions chosen for the experimental design, it was not possible for the authors to separate the main effects of the two variables.

[57] Informational equivalence happens when all information in one representation is inferable from the other, and vice-versa (Lightner and Eastman 2002)

Table 14 Empirical work on e-shopping

Source	Variables	Context	Measures	Main findings
(Klein 2003)	User control (sequential, any order) x media richness (pictures x video)	Controlled experiment in advertising, one product only (wine or facial cream), no decision making	Telepresence, persuasion, learning (recall, recognition), attitudes	Some effects on persuasion and attitudes. No effects on learning
(Haubl and Figueroa 2002)	Interactive 3D product presentations (I3DPP)	Controlled experiments for PDA and mobile phones	Time, confidence, perceived decision difficulty, likelihood of purchasing the product, uncertainty	Subjects spent more time with I3DPP. Intention to purchase is greater for products with I3DPP.
(Jiang and Benbasat 2007)	Vividness and interactivity: static images, video with narration, video without narration, virtual product experience	Controlled experiment on preference	Perceived diagnosticity, compatibility with in-store shopping, shopping enjoyment, attitudes towards products and website, intention to purchase	Positive effects of vividness and interactivity on all measures
(Haubl and Trifts 2000)	Recommendation agent (RA) and comparison matrix (CM)	Controlled experiment for selecting a backpacking tent and a compact stereo system	Search effort, consideration set (size and quality), quality of purchase decisions	Strong favourable effects for quality and efficiency of purchase decisions
(Ariely 2000)	User control	Controlled experiments for selection of cameras	Decision quality, memory, knowledge, confidence	Positive effects. Negative effects when the task is novel or difficult
(Lee and Benbasat 2003)	Image size, clarity of image, motion	Controlled experiment for a book, a PDA and a digital camera	Attention, memory	Higher quality of pictures and motion lead to greater attention Larger images enhance memory performance for images

(Li, Daugherty et al. 2003)	Product presentation (2D, 3D) v. product type (within)	Controlled experiment in advertising, simplified decision making (buy or not buy that particular product: watch, bedding material, laptop computer)	Product knowledge, attitude, and confidence in the decision (surrogate for decision quality)	Effects on knowledge and decision quality for visual affordances (watch). No effects for tactile affordances (bedding material). Effects on knowledge for behavioural affordances.
(Teo, Lih-Bin et al. 2003)	Interactivity level (low, medium, high)	Controlled experiment on product selection (desktop computer)	Satisfaction, effectiveness, efficiency, value, attitude	Positive effects on satisfaction, effectiveness, efficiency, value, attitude
(Suh and Lee 2005)	Product presentation (static images, "virtual reality") Product type (desktop computer, computer desk)	Controlled experiment on product preference	Product knowledge, attitudes, perceived product knowledge, purchase intention	Positive effects for computer desk

4. Haubl and Trifts (2000) conducted an experiment in which the main goal was to show how interactive decision aids could influence the way consumers make decisions. Participants had to select a tent from 54 alternatives (6 different brands) and a compact stereo system from 54 alternatives (6 different brands). Each product was described using 7 attributes, 5 of which were varied systematically. The focus of the study was the two phases of evaluation of alternatives: identification (screening) and comparison of alternatives. For the identification of alternatives phase, users could select a consideration set using a recommendation agent[58]. In the comparison phase – evaluation of the selected products in detail - all that was offered was a way of comparing the (search) attributes in a matrix. The results of the experiment showed that recommendation agents produced better choices with less effort (Haubl and Trifts 2000). The problem with this experiment is that the products they used in the experiments - tents and stereo systems - were described only in terms of search attributes. For an expert in tents, it is perhaps sufficient to compare the different models based on search attributes, but for someone who is to buy a tent for the first time, the experience attributes (e.g., how the tents look like, how easy it is to assemble it) are as important as the search ones. Of course, one does not need to see or try the product again when making a habitual purchase (e.g., replacing toothpaste). However, for complex decision-making, seeing the product (perhaps for the first time) is important. It should also be mentioned that the study by Haubl and Trifts advocates the use of recommendation agents, without considering some of their limitations: recommendation agents assume that consumers have and are able to express established, well defined and stable preferences in the product category. The user has to specify precisely what he or she is looking for, which requires good product domain knowledge. As shown by Bettman, Luce et al. (1998)

[58] Recommendation agent is defined as "an electronic agent that helps identify a product most suited to consumers' needs based on information regarding preferences" (Swaminathan 2003, p. 93). Basically the consumer answers some questions involving needs, constraints and preferences – the answers are then used to produce a list of acceptable alternatives, ordered by how well they satisfy these constraints. They can be useful to identify alternatives, eliminating non-relevant ones, producing a reduced set of alternatives.

preferences for options are often constructed and not merely revealed, i.e., people often do not have well-defined preferences; instead, they may construct them on the fly when needed, such as when they must make a selection. Another problem with this type of agent is that consumers have difficulties in understanding the ordering of the suggested alternatives given by the recommendation agent, i.e., it is not clear either how the consumer's preferences affect the results or how the consideration set is calculated (Spiekermann and Parachiv 2002). Finally, as demonstrated by Widing and Talarzyk (1993), the cut-off rule that is normally employed can lead to sub-optimal decisions[59], allowing some attractive options to go unnoticed (Alba, Lynch et al. 1997).

5. In Ariely's (2000) study, five experiments testing the effect of user control over decision quality, memory, knowledge and confidence were described. User control was shown to have a positive effect on all measures. An interactive shopping environment was populated with the descriptions of nine cameras. Participants in conditions of low or high user control were asked to learn about the different cameras. In the low user control condition, it was only possible to access camera information in a pre-defined sequential order; in the high user control condition, the user chose the order. This study has the same limitations as the one by Klein (2003), in the sense that it does not expand the HCI basic principle of giving control to the user. Furthermore, participants were exposed to information about cameras as ratings on some search attributes: lens, body, shutter and engine. This means that, as in the study by Haubl and Trifts (2000), Ariely provides information only on search attributes, disregarding experience attributes.

6. Lee and Benbasat (2003) performed one lab experiment where three products were described: one book, one PDA and one digital camera. They manipulated image size (large v. small image of the product), quality of the picture showing the product (low v. high quality), and motion (static v. animated images). They found that larger images enhance memory about the products, images of better quality demand more attention, and that motion also leads to greater attention. Once again, no choice was offered; only preference.

7. Li, Daugherty et al. (2003) ran a series of experiments to investigate the effects of 3D product presentation on consumer behaviour. In the main experiment, they had participants divided in two groups (2D x 3D presentations) for three different products, selected for the following reasons:

    - a wristwatch - a geometric product for which visual inspection is most important;
    - bedding material - a material product for which tactile examination is most important;
    - and a laptop computer - a mechanical product for which behavioural inspection is most important.

    They measured product knowledge, brand attitude and purchase decision quality (in reality, only confidence in buying or not buying that particular product). They found significant effects of 3D over 2D presentations for product knowledge and decision quality when visual inspection was most relevant (wristwatch). They found no differences for the material product (bedding material). Finally, for the mechanical product (laptop computer), only product knowledge was significantly different. One of the main contributions of this study is the recognition that different types of products (geometric, material and mechanical) have different ways of being inspected. However, the study contains some problems. First, one limitation admitted by the authors was the stimulus for the mechanical product: the behavioural manipulation of the laptop computer representation was extremely limited - participants were

[59] The study by Widing and Talarzyk (1993) shows that a non-compensatory cut-off-based strategy, normally applied by recommendation agents to simplify the decision, "can lead to premature elimination of a preferred alternative." (p. 127).

only able to open and close the lid, remove the battery and power on the computer. For this reason the authors found the results for behavioural inspection inconclusive. The second problem is the use of only one instance of a product, where no choice is required; so, as with the works of Klein (2003) and Lee and Benbasat (2003), the study is more relevant for marketing and advertising than for consumer decision-making. Finally, product descriptions consisted almost entirely of visual cues, with little textual information, restricting the access to search attributes. For example, in the case of the laptop computer there was no technical specification, not even the microprocessor, which is a basic search attribute of any computer. It is then difficult to judge a product on its search attributes if indirect experience is not provided (Wright and Lynch 1995).

8. Teo, Lih-Bin et al. (2003) measured satisfaction, effectiveness, efficiency, value and attitude against interactivity level for users shopping for a computer system. They reported that they were all positively affected by interactivity level. The measurements of effectiveness and efficiency were done post-hoc, based on questionnaires. In this case they were measuring perceived effectiveness and efficiency which is not the same as observed effectiveness and efficiency. Because their research model considers value and attitude to be a function of the other three variables, the authors' claims cannot be substantiated.

9. Suh and Lee (2005) in a preference study measured objective and perceived product knowledge, attitudes, purchase intentions for two products: a desktop computer (literally only the computer cabinet) and a computer desk, represented by static pictures in one condition and by what the authors call virtual reality (actually a 3D model of the product) in another. The authors concluded that the 3D representation was more effective for the computer desk since it is dominated by experience attributes.

8.2.1 Conclusions from previous empirical work

Previous research on electronic shopping has examined consumer behaviour relative to electronic advertising based on preference models (Klein 2003; Lee and Benbasat 2003; Li, Daugherty et al. 2003), has not taken into account user needs (Haubl and Trifts 2000; Lee and Benbasat 2003), has used unrealistic and over-simplistic environments (Ariely 2000; Haubl and Trifts 2000; Lee and Benbasat 2003), has used very restrictive product inspection (Haubl and Figueroa 2002; Lee and Benbasat 2003; Li, Daugherty et al. 2003), or unreliable measurements (Teo, Lih-Bin et al. 2003). Furthermore, when comparison tools were used, they described products using only search attributes (Haubl and Trifts 2000).

The approach taken by this thesis is to use a realistic e-shopping environment for complex decision-making in a rational choice model research paradigm, where consumers can assess and compare both products' search and experience attributes, capturing a rich set of objective and subjective data. By assessing features such as media allocation, exploration and naturalness, the present study aims to understand the effects of the application of multimedia features formulated in this thesis.

A laboratory experiment was carried out to partially test the multimedia features using the e-shopping environment described in Chapter 7. Participants used one version of an e-store where interactive product demos and comparators were manipulated. The remainder of this chapter describes the experiment in detail and presents the results obtained.

8.3 Independent variables

Two independent variables were used:

1) *Comparison tools* (CT) – type of interactive decision aid[60] that is designed to assist consumers in making in-depth comparisons among the alternatives (Haubl and Trifts 2000).
2) *Multimedia product demo* (MM) – allows consumers to learn about the product before making a purchase decision.

Comparison tools and multimedia product demo were manipulated independently in order to measure their independent and joint effects on user choice, learning, efficiency, and subjective measures: satisfaction, perceived ease of use, perceived naturalness/realness, attitudes towards digital cameras and the website, beliefs, perceived quality of the decisions and perceived knowledge about the cameras.

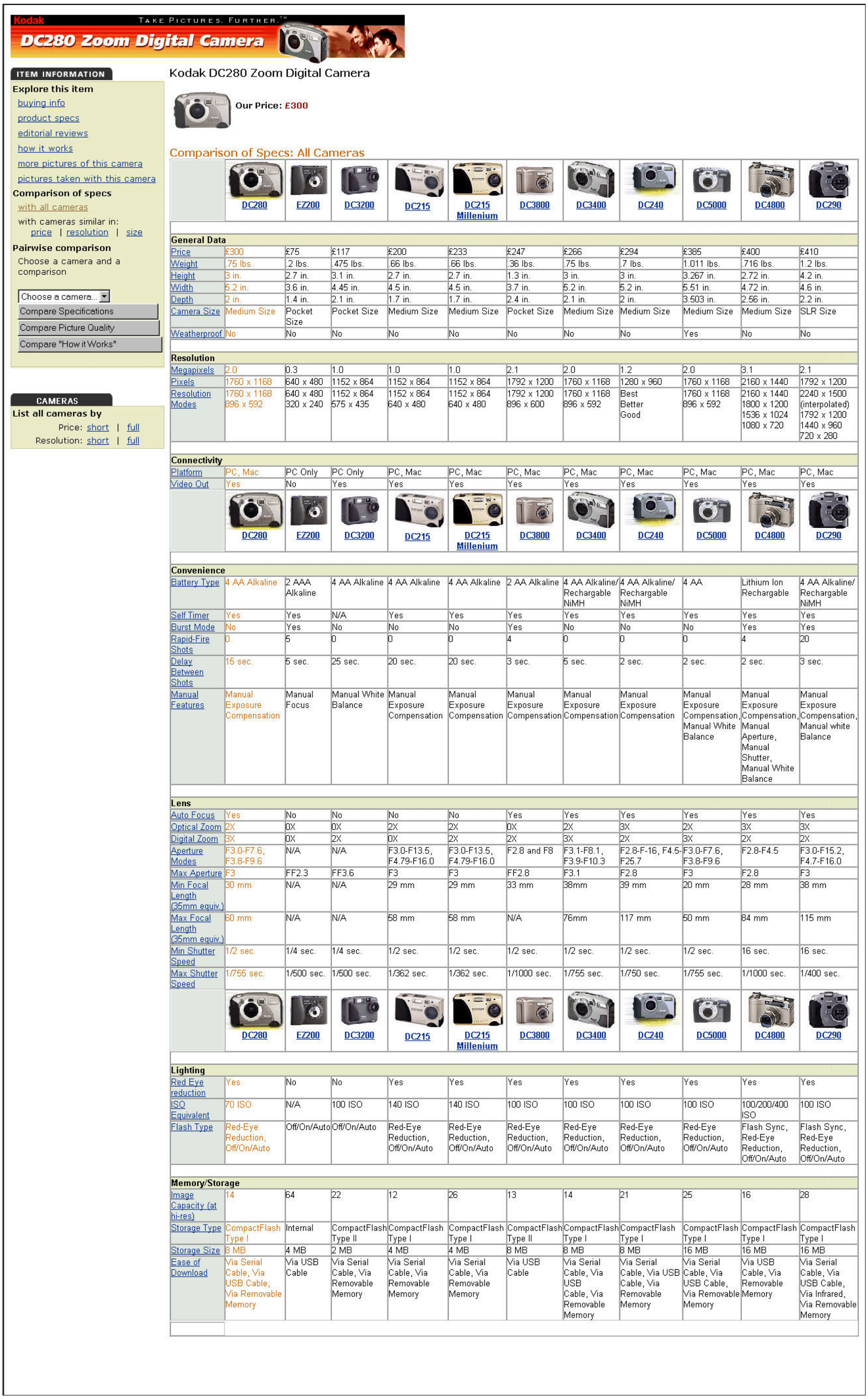
8.3.1 Comparison tools (CT) conditions:

The independent variable *CT* was manipulated by presenting the condition to one group of participants and withholding for another group (presence or absence technique). It could take on two values: No-CT, in which comparison tools were absent; and CT, in which comparison tools were present. In the CT conditions, participants were able to make four types of comparisons:

a) Comparison of specifications: all the specifications of the selected camera are compared to the other cameras, shown in a table (Figure 46). The current camera (in the case of the figure, DC280) appears in the first column and in a distinct colour; the other cameras are ordered by price. The attributes are presented in the rows.

b) Comparison with cameras similar in one aspect: price, resolution or size. This is a special case of the previous item (comparison of specifications), where a table of specifications is presented, but now with only those cameras that match the criteria (Figure 47).

[60] Interactive decision aid, as defined by Haubl and Trifts (2000), is an interactive feature that assists shoppers in making purchase decisions.



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how it works
more pictures of this camera
pictures taken with this camera

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with all cameras
with cameras similar in:
price | resolution | size

Pairwise comparison

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Choose a camera...
Compare Specifications
Compare Picture Quality
Compare "How it Works"

CAMERAS

List all cameras by

Price: short | full
Resolution: short | full

Kodak DC280 Zoom Digital Camera

Our Price: £300

Comparison of Specs: All Cameras

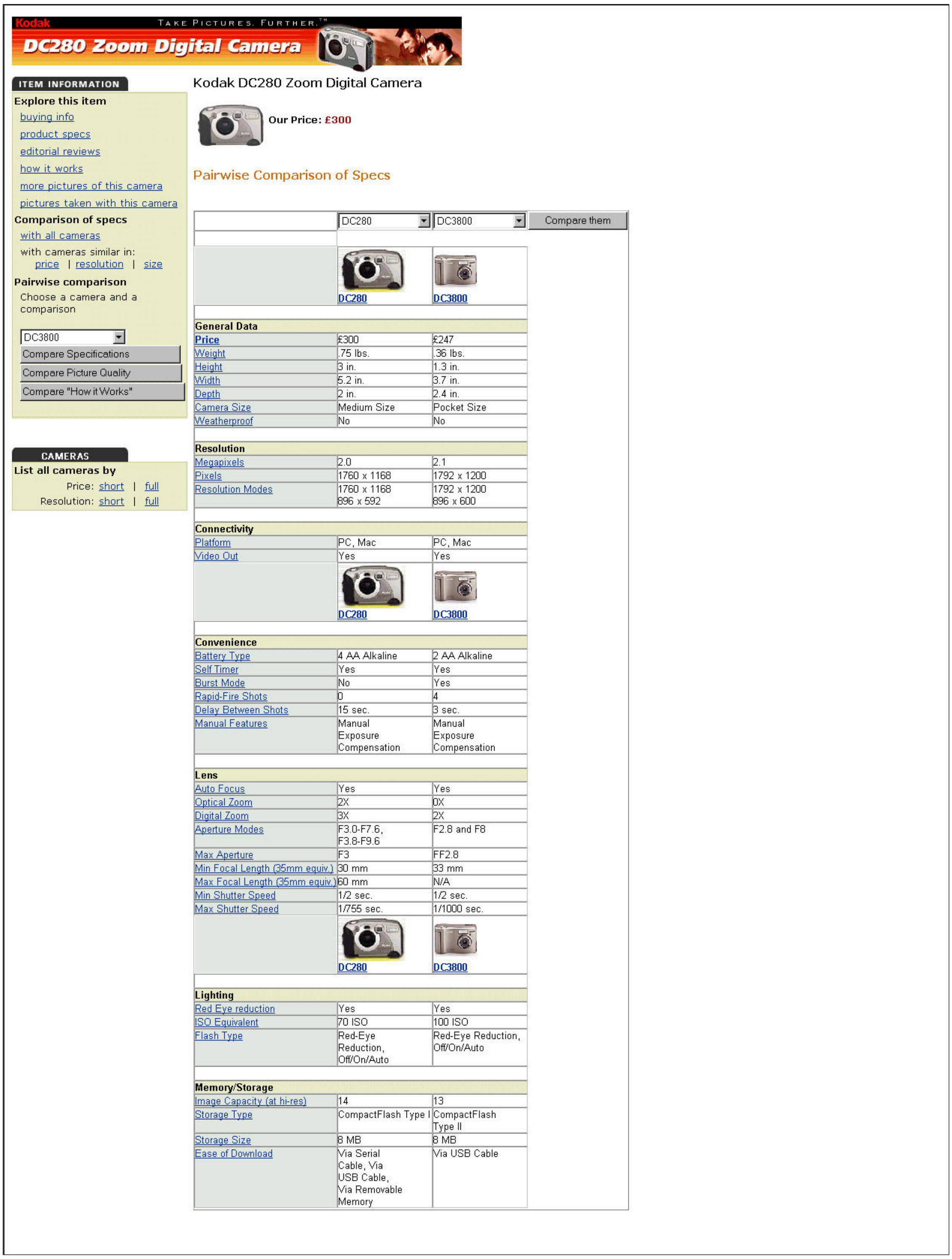
	DC280	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC5000	DC4800	DC290
General Data											
Price	£300	£75	£117	£200	£233	£247	£266	£294	£385	£400	£410
Weight	.75 lbs.	.2 lbs.	.475 lbs.	.66 lbs.	.66 lbs.	.36 lbs.	.75 lbs.	.7 lbs.	1.011 lbs.	.716 lbs.	1.2 lbs.
Height	3 in.	2.7 in.	3.1 in.	2.7 in.	2.7 in.	1.3 in.	3 in.	3 in.	3.267 in.	2.72 in.	4.2 in.
Width	5.2 in.	3.6 in.	4.45 in.	4.5 in.	4.5 in.	3.7 in.	5.2 in.	5.2 in.	5.51 in.	4.72 in.	4.6 in.
Depth	2 in.	1.4 in.	2.1 in.	1.7 in.	1.7 in.	2.4 in.	2.1 in.	2 in.	3.503 in.	2.56 in.	2.2 in.
Camera Size	Medium Size	Pocket Size	Pocket Size	Medium Size	Medium Size	Pocket Size	Medium Size	Medium Size	Medium Size	Medium Size	SLR Size
Weatherproof	No	No	No	No	No	No	No	No	Yes	No	No
Resolution											
Megapixels	2.0	0.3	1.0	1.0	1.0	2.1	2.0	1.2	2.0	3.1	2.1
Pixels	1760 x 1168	640 x 480	1152 x 864	1152 x 864	1152 x 864	1792 x 1200	1760 x 1168	1280 x 960	1760 x 1168	2160 x 1440	1792 x 1200
Resolution Modes	1760 x 1168 896 x 592	640 x 480 320 x 240	1152 x 864 575 x 435	1152 x 864 640 x 480	1152 x 864 640 x 480	1792 x 1200 896 x 600	1760 x 1168 896 x 592	Best Better Good	1760 x 1168 896 x 592	2160 x 1440 1800 x 1200 1536 x 1024 1080 x 720	2240 x 1500 (interpolated) 1792 x 1200 1440 x 960 720 x 280
Connectivity											
Platform	PC, Mac	PC Only	PC Only	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac
Video Out	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	DC280	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC5000	DC4800	DC290
Convenience											
Battery Type	4 AA Alkaline	2 AAA Alkaline	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline	2 AA Alkaline	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline/ Rechargable NiMH	4 AA	Lithium Ion Rechargable	4 AA Alkaline/ Rechargable NiMH
Self Timer	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Burst Mode	No	Yes	No	No	No	Yes	No	No	No	Yes	Yes
Rapid-Fire Shots	0	5	0	0	0	4	0	0	0	4	20
Delay Between Shots	15 sec.	5 sec.	25 sec.	20 sec.	20 sec.	3 sec.	5 sec.	2 sec.	2 sec.	2 sec.	3 sec.
Manual Features	Manual Exposure Compensation	Manual Focus	Manual White Balance	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation, Manual White Balance	Manual Exposure Compensation, Manual Aperture, Manual Shutter, Manual White Balance	Manual Exposure Compensation, Manual white Balance
Lens											
Auto Focus	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Optical Zoom	2X	0X	0X	2X	2X	0X	2X	3X	2X	3X	3X
Digital Zoom	3X	0X	2X	0X	2X	2X	3X	2X	3X	2X	2X
Aperture Modes	F3.0-F7.6, F3.8-F9.6	N/A	N/A	F3.0-F13.5, F4.79-F16.0	F3.0-F13.5, F4.79-F16.0	F2.8 and F8	F3.1-F8.1, F3.9-F10.3	F2.8-F-16, F4.5-F25.7	F3.0-F7.6, F3.8-F9.6	F2.8-F4.5	F3.0-F15.2, F4.7-F16.0
Max Aperture	F3	FF2.3	FF3.6	F3	F3	FF2.8	F3.1	F2.8	F3	F2.8	F3
Min Focal Length (35mm equiv.)	30 mm	N/A	N/A	29 mm	29 mm	33 mm	38mm	39 mm	20 mm	28 mm	38 mm
Max Focal Length (35mm equiv.)	60 mm	N/A	N/A	58 mm	58 mm	N/A	76mm	117 mm	50 mm	84 mm	115 mm
Min Shutter Speed	1/2 sec.	1/4 sec.	1/4 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	16 sec.	16 sec.
Max Shutter Speed	1/755 sec.	1/500 sec.	1/500 sec.	1/362 sec.	1/362 sec.	1/1000 sec.	1/755 sec.	1/750 sec.	1/755 sec.	1/1000 sec.	1/400 sec.
	DC280	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC5000	DC4800	DC290
Lighting											
Red Eye reduction	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ISO Equivalent	70 ISO	N/A	100 ISO	140 ISO	140 ISO	100 ISO	100 ISO	100 ISO	100 ISO	100/200/400 ISO	100 ISO
Flash Type	Red-Eye Reduction, Off/On/Auto	Off/On/Auto	Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Flash Sync, Red-Eye Reduction, Off/On/Auto	Flash Sync, Red-Eye Reduction, Off/On/Auto
Memory/Storage											
Image Capacity (at hi-res)	14	64	22	12	26	13	14	21	25	16	28
Storage Type	CompactFlash Type I	Internal	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I
Storage Size	8 MB	4 MB	2 MB	4 MB	4 MB	8 MB	8 MB	8 MB	16 MB	16 MB	16 MB
Ease of Download	Via Serial Cable, Via USB Cable, Via Removable Memory	Via USB Cable	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via USB Cable	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Infrared, Via Removable Memory

Figure 46 Comparison of specifications of camera DC280 with all others

	DC280	DC215	DC215 Millenium	DC3800	DC3400	DC240
General Data						
Price	£300	£200	£233	£247	£266	£294
Weight	.75 lbs.	.66 lbs.	.66 lbs.	.36 lbs.	.75 lbs.	.7 lbs.
Height	3 in.	2.7 in.	2.7 in.	1.3 in.	3 in.	3 in.
Width	5.2 in.	4.5 in.	4.5 in.	3.7 in.	5.2 in.	5.2 in.
Depth	2 in.	1.7 in.	1.7 in.	2.4 in.	2.1 in.	2 in.
Camera Size	Medium Size	Medium Size	Medium Size	Pocket Size	Medium Size	Medium Size
Weatherproof	No	No	No	No	No	No
Resolution						
Megapixels	2.0	1.0	1.0	2.1	2.0	1.2
Pixels	1760 x 1168	1152 x 864	1152 x 864	1792 x 1200	1760 x 1168	1280 x 960
Resolution Modes	1760 x 1168 896 x 592	1152 x 864 640 x 480	1152 x 864 640 x 480	1792 x 1200 896 x 600	1760 x 1168 896 x 592	Best Better Good
Connectivity						
Platform	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac
Video Out	Yes	Yes	Yes	Yes	Yes	Yes
	DC280	DC215	DC215 Millenium	DC3800	DC3400	DC240
Convenience						
Battery Type	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline	2 AA Alkaline	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline/ Rechargable NiMH
Self Timer	Yes	Yes	Yes	Yes	Yes	Yes
Burst Mode	No	No	No	Yes	No	No
Rapid-Fire Shots	0	0	0	4	0	0
Delay Between Shots	15 sec.	20 sec.	20 sec.	3 sec.	5 sec.	2 sec.
Manual Features	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation
Lens						
Auto Focus	Yes	No	No	Yes	Yes	Yes
Optical Zoom	2X	2X	2X	0X	2X	3X
Digital Zoom	3X	0X	2X	2X	3X	2X
Aperture Modes	F3.0-F7.6, F3.8-F9.6	F3.0-F13.5, F4.79-F16.0	F3.0-F13.5, F4.79-F16.0	F2.8 and F8	F3.1-F8.1, F3.9-F10.3	F2.8-F-16, F4.5-F25.7
Max Aperture	F3	F3	F3	FF2.8	F3.1	F2.8
Min Focal Length (35mm equiv.)	30 mm	29 mm	29 mm	33 mm	38mm	39 mm
Max Focal Length (35mm equiv.)	60 mm	58 mm	58 mm	N/A	76mm	117 mm
Min Shutter Speed	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.
Max Shutter Speed	1/755 sec.	1/362 sec.	1/362 sec.	1/1000 sec.	1/755 sec.	1/750 sec.
	DC280	DC215	DC215 Millenium	DC3800	DC3400	DC240
Lighting						
Red Eye reduction	Yes	Yes	Yes	Yes	Yes	Yes
ISO Equivalent	70 ISO	140 ISO	140 ISO	100 ISO	100 ISO	100 ISO
Flash Type	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto
Memory/Storage						
Image Capacity (at hi-res)	14	12	26	13	14	21
Storage Type	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I
Storage Size	8 MB	4 MB	4 MB	8 MB	8 MB	8 MB
Ease of Download	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via USB Cable	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory

Figure 47 Comparison of specifications of DC280 with cameras similar in price

c) Pairwise comparison: in this case, it is possible to compare two cameras using three criteria: specifications, picture quality and how-it-works. The pairwise comparison of specifications (Figure 48) is a special case of the general comparison of specifications. While comparing picture quality, it is possible to compare pictures produced by two cameras, side-by-side (Figure 49). To compare the functionalities of two cameras, the pairwise comparison of how-it-works must be used, where the demos of the cameras are shown side-by-side (Figure 50).


Kodak TAKE PICTURES. FURTHER.™
DC280 Zoom Digital Camera

ITEM INFORMATION
Explore this item
buying info
product specs
editorial reviews
how it works
more pictures of this camera
pictures taken with this camera
Comparison of specs
with all cameras
with cameras similar in:
price | resolution | size
Pairwise comparison
Choose a camera and a comparison
DC3800
Compare Specifications
Compare Picture Quality
Compare "How it Works"

CAMERAS
List all cameras by
Price: short | full
Resolution: short | full

Kodak DC280 Zoom Digital Camera

Our Price: £300

Pairwise Comparison of Specs

DC280 | DC3800 | Compare them

	DC280	DC3800
General Data		
Price	£300	£247
Weight	.75 lbs.	.36 lbs.
Height	3 in.	1.3 in.
Width	5.2 in.	3.7 in.
Depth	2 in.	2.4 in.
Camera Size	Medium Size	Pocket Size
Weatherproof	No	No
Resolution		
Megapixels	2.0	2.1
Pixels	1760 x 1168	1792 x 1200
Resolution Modes	1760 x 1168 896 x 592	1792 x 1200 896 x 600
Connectivity		
Platform	PC, Mac	PC, Mac
Video Out	Yes	Yes
	DC280	DC3800
Convenience		
Battery Type	4 AA Alkaline	2 AA Alkaline
Self Timer	Yes	Yes
Burst Mode	No	Yes
Rapid-Fire Shots	0	4
Delay Between Shots	15 sec.	3 sec.
Manual Features	Manual Exposure Compensation	Manual Exposure Compensation
Lens		
Auto Focus	Yes	Yes
Optical Zoom	2X	0X
Digital Zoom	3X	2X
Aperture Modes	F3.0-F7.6, F3.8-F9.6	F2.8 and F8
Max Aperture	F3	FF2.8
Min Focal Length (35mm equiv.)	30 mm	33 mm
Max Focal Length (35mm equiv.)	60 mm	N/A
Min Shutter Speed	1/2 sec.	1/2 sec.
Max Shutter Speed	1/755 sec.	1/1000 sec.
	DC280	DC3800
Lighting		
Red Eye reduction	Yes	Yes
ISO Equivalent	70 ISO	100 ISO
Flash Type	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto
Memory/Storage		
Image Capacity (at hi-res)	14	13
Storage Type	CompactFlash Type I	CompactFlash Type II
Storage Size	8 MB	8 MB
Ease of Download	Via Serial Cable, Via USB Cable, Via Removable Memory	Via USB Cable

Figure 48 Pairwise comparison of specifications

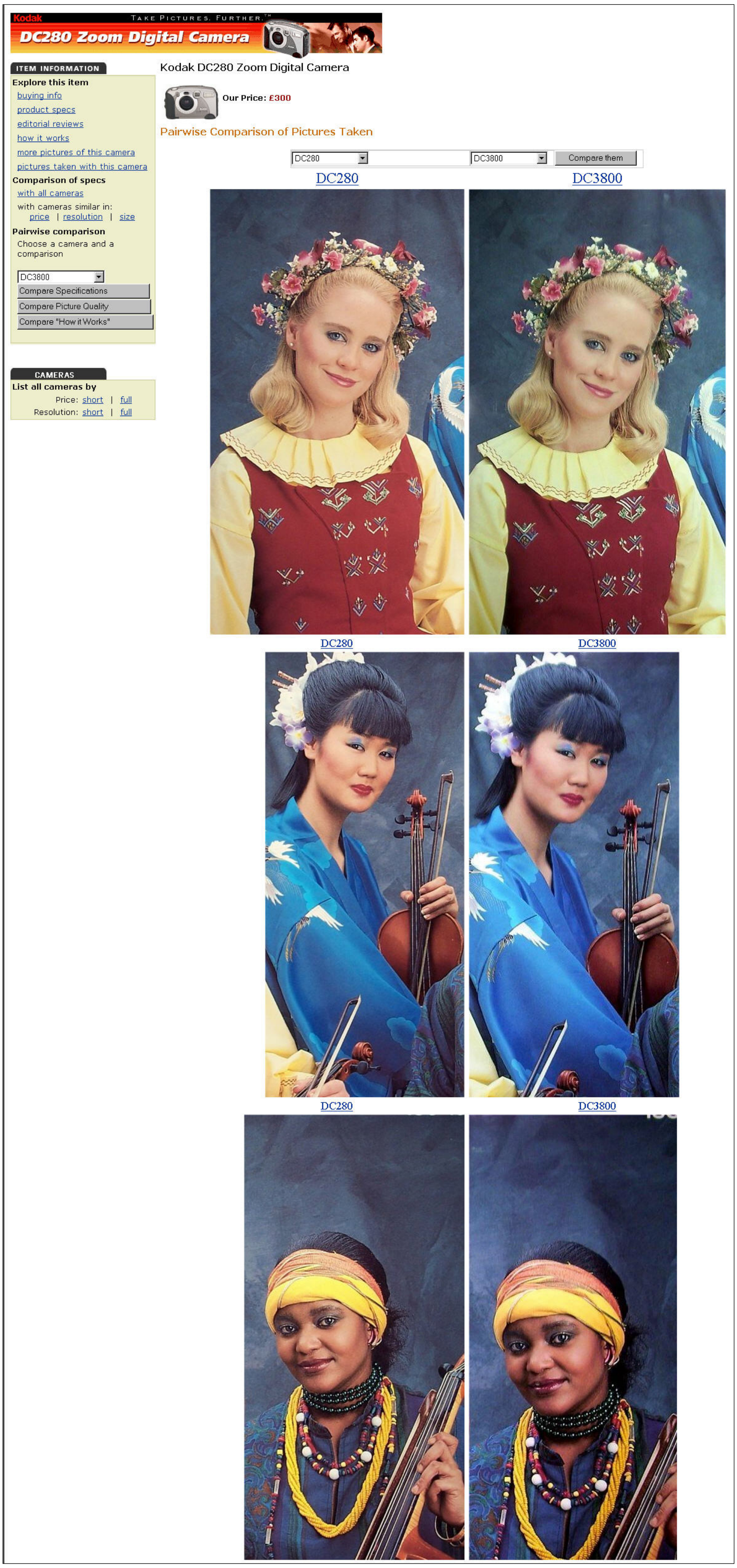
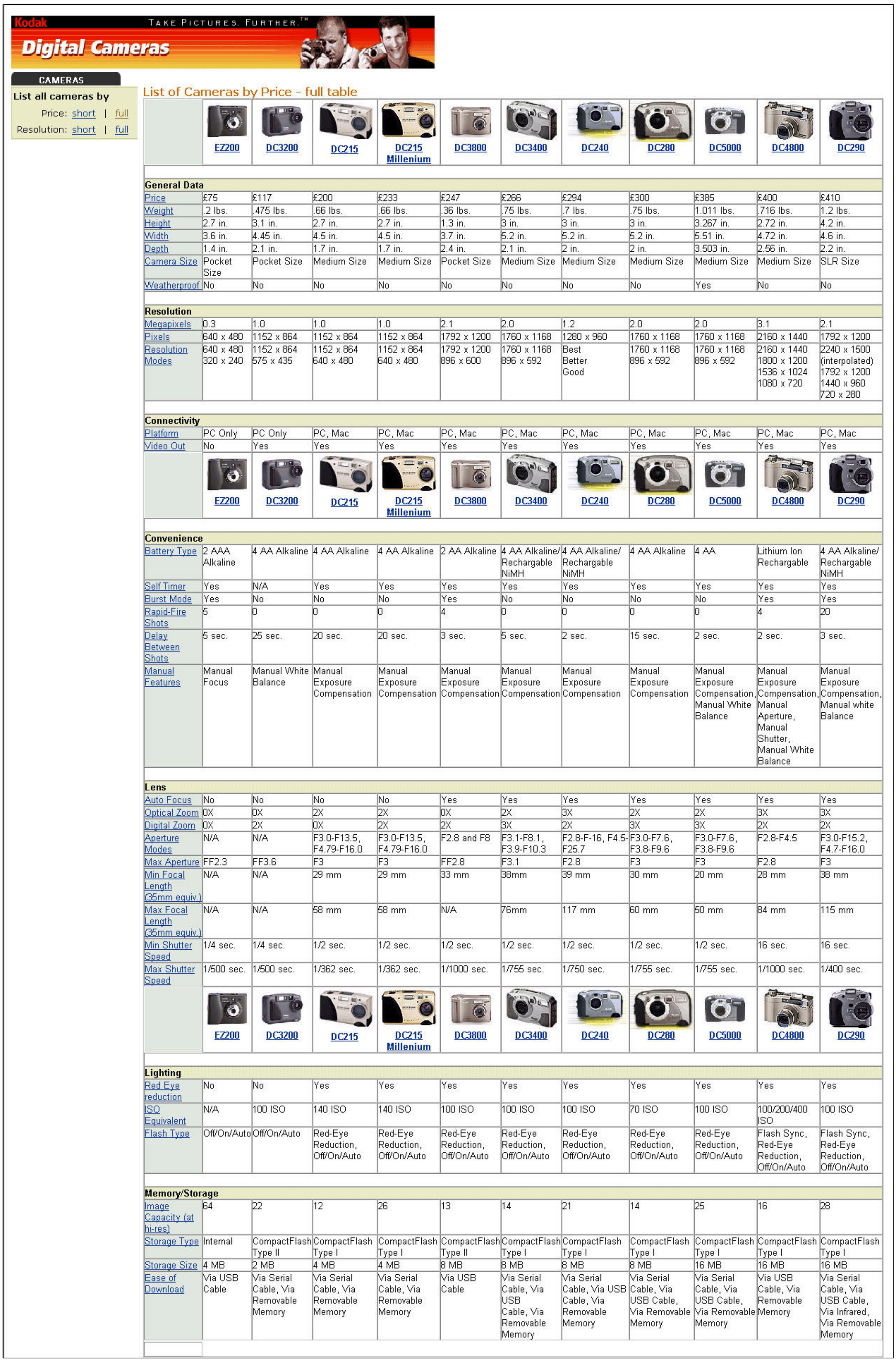


Figure 49 Pairwise comparison of picture quality

Figure 50 Pairwise comparison of how-it-works

d) List of all cameras: shows a table comparing the specifications of all cameras. It is accessed in the CAMERAS sub-menu, where it is possible to select a full table (Figure 51) or a short table (Figure 52); it is also possible to sort it by price or resolution.



Kodak TAKE PICTURES. FURTHER.™

Digital Cameras

CAMERAS

List all cameras by

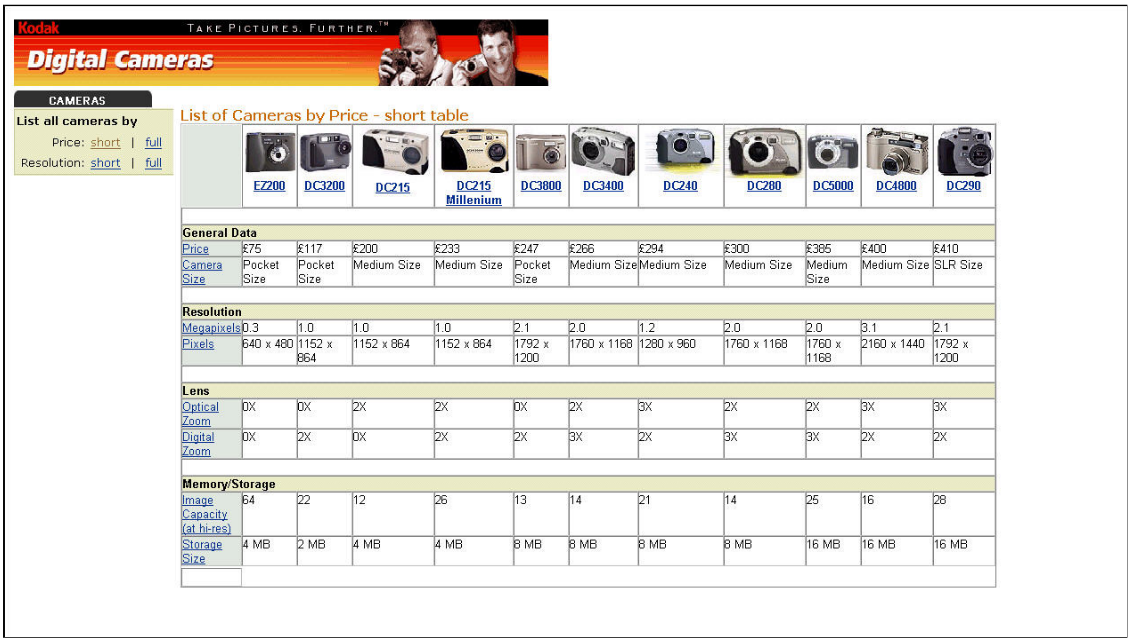
Price: short | full

Resolution: short | full

List of Cameras by Price - full table

	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC280	DC5000	DC4800	DC290
General Data											
Price	£75	£117	£200	£233	£247	£266	£294	£300	£385	£400	£410
Weight	.2 lbs.	.475 lbs.	.66 lbs.	.66 lbs.	.36 lbs.	.75 lbs.	.7 lbs.	.75 lbs.	1.011 lbs.	.716 lbs.	1.2 lbs.
Height	2.7 in.	3.1 in.	2.7 in.	2.7 in.	1.3 in.	3 in.	3 in.	3 in.	3.267 in.	2.72 in.	4.2 in.
Width	3.6 in.	4.45 in.	4.5 in.	4.5 in.	3.7 in.	5.2 in.	5.2 in.	5.2 in.	5.51 in.	4.72 in.	4.6 in.
Depth	1.4 in.	2.1 in.	1.7 in.	1.7 in.	2.4 in.	2.1 in.	2 in.	2 in.	3.503 in.	2.56 in.	2.2 in.
Camera Size	Pocket Size	Pocket Size	Medium Size	Medium Size	Pocket Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	SLR Size
Weatherproof	No	No	No	No	No	No	No	No	Yes	No	No
Resolution											
Megapixels	0.3	1.0	1.0	1.0	2.1	2.0	1.2	2.0	2.0	3.1	2.1
Pixels	640 x 480	1152 x 864	1152 x 864	1152 x 864	1792 x 1200	1760 x 1168	1280 x 960	1760 x 1168	1760 x 1168	2160 x 1440	1792 x 1200
Resolution Modes	640 x 480 320 x 240	1152 x 864 575 x 435	1152 x 864 640 x 480	1152 x 864 640 x 480	1792 x 1200 896 x 600	1760 x 1168 896 x 592	Best Better Good	1760 x 1168 896 x 592	1760 x 1168 896 x 592	2160 x 1440 1800 x 1200 1536 x 1024 1080 x 720	2240 x 1500 (interpolated) 1792 x 1200 1440 x 960 720 x 280
Connectivity											
Platform	PC Only	PC Only	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac	PC, Mac
Video Out	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC280	DC5000	DC4800	DC290
Convenience											
Battery Type	2 AAA Alkaline	4 AA Alkaline	4 AA Alkaline	4 AA Alkaline	2 AA Alkaline	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline/ Rechargable NiMH	4 AA Alkaline	4 AA	Lithium Ion Rechargable	4 AA Alkaline/ Rechargable NiMH
Self Timer	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Burst Mode	Yes	No	No	No	Yes	No	No	No	No	Yes	Yes
Rapid-Fire Shots	5	0	0	0	4	0	0	0	0	4	20
Delay Between Shots	5 sec.	25 sec.	20 sec.	20 sec.	3 sec.	5 sec.	2 sec.	15 sec.	2 sec.	2 sec.	3 sec.
Manual Features	Manual Focus	Manual White Balance	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation	Manual Exposure Compensation, Manual White Balance	Manual Exposure Compensation, Manual Aperture, Manual Shutter, Manual White Balance	Manual Exposure Compensation, Manual white Balance
Lens											
Auto Focus	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Optical Zoom	0X	0X	2X	2X	0X	2X	3X	2X	2X	3X	3X
Digital Zoom	0X	2X	0X	2X	2X	3X	2X	3X	3X	2X	2X
Aperture Modes	N/A	N/A	F3.0-F13.5, F4.79-F16.0	F3.0-F13.5, F4.79-F16.0	F2.8 and F8	F3.1-F8.1, F3.9-F10.3	F2.8-F-16, F4.5-F25.7	F3.0-F7.6, F3.8-F9.6	F3.0-F7.6, F3.8-F9.6	F2.8-F4.5	F3.0-F15.2, F4.7-F16.0
Max Aperture	FF2.3	FF3.6	F3	F3	FF2.8	F3.1	F2.8	F3	F3	F2.8	F3
Min Focal Length (35mm equiv.)	N/A	N/A	29 mm	29 mm	33 mm	38mm	39 mm	30 mm	20 mm	28 mm	38 mm
Max Focal Length (35mm equiv.)	N/A	N/A	58 mm	58 mm	N/A	76mm	117 mm	60 mm	50 mm	84 mm	115 mm
Min Shutter Speed	1/4 sec.	1/4 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	1/2 sec.	16 sec.	16 sec.
Max Shutter Speed	1/500 sec.	1/500 sec.	1/362 sec.	1/362 sec.	1/1000 sec.	1/755 sec.	1/750 sec.	1/755 sec.	1/755 sec.	1/1000 sec.	1/400 sec.
	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC280	DC5000	DC4800	DC290
Lighting											
Red Eye reduction	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ISO Equivalent	N/A	100 ISO	140 ISO	140 ISO	100 ISO	100 ISO	100 ISO	70 ISO	100 ISO	100/200/400 ISO	100 ISO
Flash Type	Off/On/Auto	Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Red-Eye Reduction, Off/On/Auto	Flash Sync, Red-Eye Reduction, Off/On/Auto	Flash Sync, Red-Eye Reduction, Off/On/Auto
Memory/Storage											
Image Capacity (at hi-res)	64	22	12	26	13	14	21	14	25	16	28
Storage Type	Internal	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I	CompactFlash Type II	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I	CompactFlash Type I
Storage Size	4 MB	2 MB	4 MB	4 MB	8 MB	8 MB	8 MB	8 MB	16 MB	16 MB	16 MB
Ease of Download	Via USB Cable	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via Serial Cable, Via Removable Memory	Via USB Cable	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Removable Memory	Via USB Cable, Via Removable Memory	Via Serial Cable, Via USB Cable, Via Infrared, Via Removable Memory

Figure 51 Full table showing all cameras sorted by price



	EZ200	DC3200	DC215	DC215 Millenium	DC3800	DC3400	DC240	DC280	DC5000	DC4800	DC290
General Data											
Price	£75	£117	£200	£233	£247	£266	£294	£300	£385	£400	£410
Camera Size	Pocket Size	Pocket Size	Medium Size	Medium Size	Pocket Size	Medium Size	Medium Size	Medium Size	Medium Size	Medium Size	SLR Size
Resolution											
Megapixels	0.3	1.0	1.0	1.0	2.1	2.0	1.2	2.0	2.0	3.1	2.1
Pixels	640 x 480	1152 x 864	1152 x 864	1152 x 864	1792 x 1200	1760 x 1168	1280 x 960	1760 x 1168	1760 x 1168	2160 x 1440	1792 x 1200
Lens											
Optical Zoom	0X	0X	2X	2X	0X	2X	3X	2X	2X	3X	3X
Digital Zoom	0X	2X	0X	2X	2X	3X	2X	3X	3X	2X	2X
Memory/Storage											
Image Capacity (at hi-res)	64	22	12	26	13	14	21	14	25	16	28
Storage Size	4 MB	2 MB	4 MB	4 MB	8 MB	8 MB	8 MB	8 MB	16 MB	16 MB	16 MB

Figure 52 Short table showing all cameras sorted by price

It is important to note that from any table the user can go to the page describing a particular camera simply by clicking on the picture or name of the desired camera.

Usually, to cope with the amount of alternatives in a decision-making process, consumers typically use phased selection strategies that reflect the adaptability of consumer behaviour. Non-compensatory strategies are used first to screen the alternatives to a more manageable set of alternatives in the elimination phase. Remaining alternatives are then compared more carefully using compensatory methods. Though this prototype is more focused on the second phase, the comparison tables enable shoppers to compare products with the intention to support these activities. Furthermore, the pairwise comparison of picture quality goes a step beyond the simple comparison of specifications by providing comparisons of products' performances. More specifically, pictures produced by different cameras can be compared side-by-side (Figure 49) and consumers can actually see the difference in the quality obtained by the cameras. The same is valid for comparison of how-it-works: it is possible to compare details of the operation of two different cameras side-by-side (Figure 50).

8.3.2 No comparison tools (No-CT) conditions

When comparison tools are not available, the system will not support comparisons – these options are not present in the menus (Figure 53). It is only possible to examine information of one single camera at a time; to access another camera, the menu CAMERAS has to be used, where a list of cameras is presented sorted either by price or resolution.

As reflected in the hypotheses, it is expected that without the facilities provided by the comparison tools, the decision-making process will be more difficult. The reason is that it becomes difficult to evaluate the different attributes using any of the different strategies, non-compensatory or compensatory ones. The cognitive effort is higher, because the consumer has to use a memory-based process to compare the different attributes of the different products.

It is important to note, though, that while the No-CT condition has less functionality compared to the CT condition, exactly the same information is provided for all cameras.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DC280 Zoom Digital Camera

ITEM INFORMATION
Explore this item
buying info
product specs
editorial reviews
how it works
more pictures of this camera
pictures taken with this camera

CAMERAS
List all cameras by
Price
Resolution

Kodak DC280 Zoom Digital Camera

Our Price: £300

Product specs

	DC280
General Data	
Price	£300
Weight	.75 lbs.
Height	3 in.
Width	5.2 in.
Depth	2 in.
Camera Size	Medium Size
Weatherproof	No
Resolution	
Megapixels	2.0
Pixels	1760 x 1168
Resolution Modes	1760 x 1168 896 x 592
Connectivity	
Platform	PC, Mac
Video Out	Yes
	DC280
Convenience	
Battery Type	4 AA Alkaline
Self Timer	Yes
Burst Mode	No
Rapid-Fire Shots	0
Delay Between Shots	15 sec.
Manual Features	Manual Exposure Compensation
Lens	
Auto Focus	Yes
Optical Zoom	2X
Digital Zoom	3X
Aperture Modes	F3.0-F7.6, F3.8-F9.6
Max Aperture	F3
Min Focal Length (35mm equiv.)	30 mm
Max Focal Length (35mm equiv.)	60 mm
Min Shutter Speed	1/2 sec.
Max Shutter Speed	1/755 sec.
	DC280
Lighting	
Red Eye reduction	Yes
ISO Equivalent	70 ISO
Flash Type	Red-Eye Reduction, Off/On/Auto
Memory/Storage	
Image Capacity (at hi-res)	14
Storage Type	CompactFlash Type I
Storage Size	8 MB
Ease of Download	Via Serial Cable, Via USB Cable, Via Removable Memory

Figure 53 Conditions where comparison tools are not available

8.3.3 Multimedia (MM) conditions

The independent variable MM was manipulated by the type of multimedia used. It could take on two values: SMPP (Static Multimedia Product Presentation), in which the products' demos were presented with static images (Figure 54); and IMPE (Interactive Multimedia Product Experience), in which participants could interact with the product through animations (Figure 55). So, in theory, in the SMPP condition, the experience attributes are more difficult to acquire - reading descriptions of the workings of the camera illustrated with some pictures. On the other hand, in the IMPE condition, the experience attributes are presented in a way that is more congruent with the task, where it is possible to interact with a model of the camera.

Care was taken so that the information content is equivalent in both conditions as to avoid potential confounding effects in the experiment (Lightner and Eastman 2002). The size of the images in how-it-works section was kept constant as it is known that the size of the image have an effect in users' reaction (Reeves and Nass 1996; Lee and Benbasat 2003).

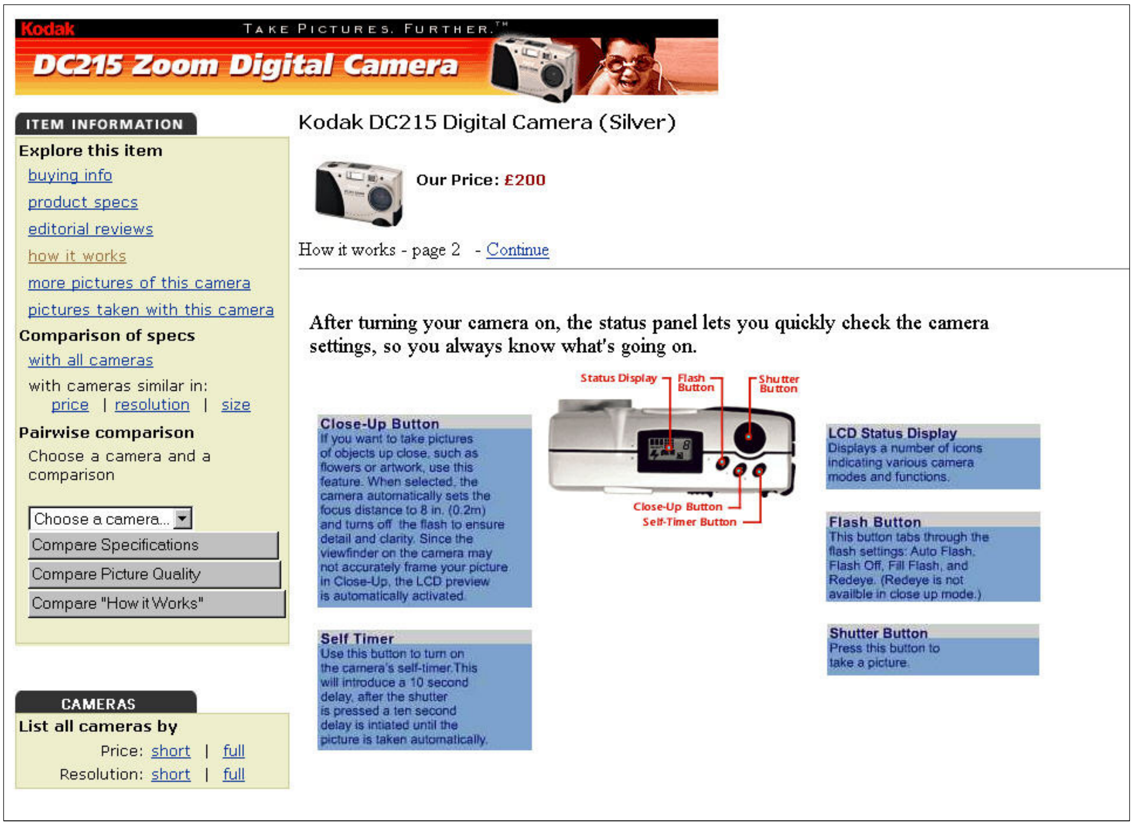

Figure 54 SMPP conditions - demo of the camera using static pictures

Figure 55 IMPE conditions - demo of the camera using an interactive animation

8.3.4 Overview of the conditions

By combining the two levels of each independent variable, four versions of the website were produced. Table 15 summarises the conditions in the experiment. The main difference across the No-CT and CT conditions was the availability of functions that allowed users to make the comparisons. Across the SMPP and IMPE conditions, to keep information constant, all steps included in the demonstrations had two versions: one static, using text and pictures, and one animated. So, every single step in a static demonstration has a counterpart step in the dynamic one, and vice-versa. The prototype of the website aims to be realistic, using real and current (at the time) information.

Table 15 Summary of conditions

Comparisons		Multimedia: SMPP	Multimedia: IMPE
	No-CT	No comparison tables	No comparison tables
		No pairwise comparisons of picture quality or demonstrations	No pairwise comparisons of picture quality or demonstrations
		Demonstrations use static pictures and text	Demonstrations use interactive animations
	CT	Comparison tables of specifications of all cameras sorted by price or resolution	Comparison tables of specifications of all cameras sorted by price or resolution
		Comparison tables of cameras similar in price, size or resolution	Comparison tables of cameras similar in price, size or resolution
		Pairwise comparisons of specifications, picture quality and demonstrations	Pairwise comparisons of specifications, picture quality and demonstrations
		Demonstrations use static pictures and text	Demonstrations use interactive animations

8.4 Procedure

The experiment was conducted in a laboratory at the department of Computer Science – University of Bath. Completed answers to the tasks were automatically collected together with the elapsed time.

Participants performed the same tasks individually (in the same office, with the same computer, with the same setup) using one of the four versions of the system (Figure 56). Upon arriving at the office, they were told that the purpose of the study was to evaluate a website. The subjects were also reassured that they were not being evaluated - it was the website that was being evaluated. First, a profile questionnaire (Appendix A) was filled in, capturing basic demographics, involvement (using the involvement scale formulated by Zaichkowsky (1994)) and attitude towards Internet shopping and digital cameras.

A training session followed: participants were given a standard introductory five-minute demonstration of the website to make them familiar with the system, strictly following scripts prepared in advance to alleviate biases. They were then asked to use the website for three minutes, and after that were asked to perform seven training tasks[61] to check they had acquired the basic skills needed to perform the real experimental tasks. Any doubts or problems were solved, until the participants were confident using the website. The mean time for the training session was 20 minutes. If no problems or doubts remained, participants could start performing the shopping

[61] For example, "what's the resolution of the DC240?" and "check the quality of the pictures produced by the DC4800".

tasks[62]. On average, each participant took approximately 20 minutes (*M* = 20.4, *SD* = 8.3) to solve all 5 tasks, for a total of more than 13 hours of experimental data (the reasons for this high variability will become clear when time and efficiency are discussed in section 8.8.3). Table 16 shows average times per task.

Figure 56 A participant during the experiment

Table 16 Average task times (in minutes)

	N	Minimum	Maximum	Mean	Std. Deviation
Task 1	40	1.15	21.98	5.91	3.78
Task 2	40	2.42	12.33	6.42	2.66
Task 3	40	.98	18.47	3.89	3.01
Task 4	40	.68	6.45	2.19	1.32
Task 5	40	.90	4.08	2.03	.80
Total	40	9.03	45.73	20.44	8.35

Once a participant had completed the five tasks, he/she proceeded to the learning test (Appendix D), to see what he/she had learned from the shopping session. Next, an evaluation questionnaire organised in seven main sections was completed (Appendix C); it measured satisfaction, perceived ease of use, naturalness/realness, attitudes, beliefs, perceived quality of the decisions and perceived knowledge. Following this, the participant answered an open-ended questionnaire (Appendix E)

[62] To reduce demand effects (Smith and Swinyard 1983), just before starting to perform the tasks, participants were also told that there was no association with the brand used in the experiment.

that covered other areas, and allowed him/her to make comments about the experience with the site. Finally, a debriefing was given.

8.5 Participants

Forty students from the University of Bath took part in the experiment. They answered to call-for-volunteers messages that were put in three places:

a. e-mail list of undergraduate and graduate students in computer science;

b. web-based notice board of the University of Bath, accessed by students from different departments;

c. posters put in several places including the campus library, student's union notice board and refectories, also visible to students of any department.

The announcements were all the same, asking for volunteers in a computer-based (web) experiment. The requirement was to be familiar with browsing the web. They received six pounds in return for their participation.

From the forty participants, 25 (62.5%) were computer science students (17 undergraduates, 7 MSci and 1 PhD), 3 engineering, 3 sports science, 2 pharmacology, 2 biology, 1 architecture, 1 business, 1 chemistry, 1 economics and 1 management. All were between 18 and 31 years of age (mean age = 21.35 years, *SD* = 2.81), with 25 (62.5%) being male and 15 (37.5%) being female. On average, they have been using computers for over 8 years (M = 8.30, SD = 3.27) and accessing the web for almost 5 years (M = 4.75, SD = 1.32). They can be considered experienced web users (78% access the web several times a day, 87% at least once a day). They have all bought at least one product over the Internet. To control for variations on participant characteristics, participants were randomly assigned to one of the four treatment groups, ten persons per group[63]. Correlations between gender, age, undergraduate or post-graduate course, and the dependent variables were not significant.

8.6 Dependent Variables

The study was a 2 (comparison tools: No-CT/CT) x 2 (multimedia: SMPP/IMPE) factorial design. The two factors were manipulated between subjects.

In order to obtain a rich set of evidences from this study, multiple measurements were made by means of questionnaires before and after the main experimental tasks and by collecting performance data during the experiment. Some variables derive directly from the dimensions used in usability evaluation (ISO DIS 9241-11 (1998)):

- Effectiveness: the accuracy and completeness with which users achieve specified goals (or the extent to which a goal, or task, is achieved)
- Efficiency: the resources expended in relation to the accuracy and completeness with which users achieve goals (the amount of effort required to accomplish a goal)
- Satisfaction: the comfort and acceptability of use

Since it has been shown that effectiveness, efficiency and satisfaction do not necessarily correlate (Frokjaer, Hertzum et al. 2000), they should be considered as independent, and all should be included. Effectiveness measures usability from the point of view of the output of the interaction: in the case of this study, the quality of the solutions, i.e., the decisions made. The first component

[63] The order in which the conditions were allocated was generated using a table of (pseudo) random numbers.

of effectiveness, accuracy, refers to the quality of the decisions taken and the second component, completeness, refers to the quantity of the output in relation to a specified target level - not relevant for this study since all tasks are completed. Efficiency relates effectiveness of interaction to resources expended. It may be measured in terms of mental or physical effort, time, materials or financial costs. In this experiment, both the time on task, and the temporal efficiency measure, computed as effectiveness/task time, are used. Satisfaction, as described by ISO 9241-11, has two components: comfort and acceptability. However, ISO 9241-11 does not define in detail what these mean. The evaluation of satisfaction in the present experiment is based on well-known subjective evaluation instruments. Additional subjective measurements incorporated in this research are based on assessment instruments employed in the consumer-behaviour discipline, including some that were designed specifically for e-shopping and multimedia (these instruments will be presented in detail in section 8.8.5).

The dependent variables were:

- **Effectiveness**: objective indicator measuring decision quality, captured by participants' answers to the tasks. Decision quality can be defined by principles of coherence – for each task there is a best-fit answer, since the tasks express requirements of a third person (tasks are described in the next section).
- **Time**: measures the amount of time to reach a decision; this is an indicator of the time taken to evaluate alternatives and make a decision.
- **Efficiency**: measures the relationship between effectiveness and time and is assessed by dividing effectiveness by time;
- **Learning**: measured by an incidental learning test (Appendix SS) applied after all tasks were completed. Participants were not told they would be given a test on what they had learned at the end of the experiment. If they had known, the relevancy of this measure as an indication of an effect by any of the independent variables would have been diminished.
- **Subjective measures**: a 39-item, seven-part questionnaire (Appendix C) was used to assess subjective opinions:
    - **Satisfaction:** general satisfaction with the website;
    - **Perceived ease of use:** how easy it was to reach decisions;
    - **Naturalness/realness:** measures user's perception of naturalness and realness of the interaction;
    - **Attitudes**: evaluative reactions towards digital cameras and the website**;**
    - **Beliefs:** measures how strong the beliefs associated with the products (digital cameras) are held;
    - **Perceived quality of the decisions**: subjective indicator measuring consumer's perception of his/her achieved decision quality, in the sense that the information is perceived to be appropriate for achieving a particular goal and that the consumer feels he/she made the right purchase decision and is confident about it;
    - **Perceived knowledge:** measures the degree of knowledge participants perceive they have about the products.

8.7 The Tasks

8.7.1 Training Tasks

Training tasks were used to assess familiarity with the website functionality. They were very simple tasks, and did not involve any decision making. There were seven tasks in total:

1. What's the resolution of the DC240?
2. Find the price of the DC3800?
3. Check how the DC240 works?
4. Check the quality of the pictures produced by the DC4800.
5. What's the most expensive camera? How much does it cost?
6. How can you compare all cameras sorted by resolution?
7. Compare the picture quality of the DC240 with the DC290

8.7.2 Experimental Tasks

Participants were required to follow a set of shopping scenarios. To assure robustness, different types of tasks, describing a number of shopping situations in different levels of specificity, were used. There were five complete tasks (appendix B), presented in the same order to all subjects. For the tasks involving selection of cameras (tasks 1 to 4), participants did not express their own preferences, but rather the requirements of a known third party (e.g. 'your friend, John'; 'the insurance company Delta'; 'the department of archaeology'). The decision to use such a third-party task was made in order to achieve better measures of decision quality and accuracy. Of course the tasks of making decisions for oneself and for others are not identical nor are they independent; however the assumption taken here is that these differences do not interact with the factors manipulated in this experiment. The main disadvantage of using self-preference measurements is that it is difficult to measure accuracy[64]. As demonstrated in Ariely (2000), it is perfectly valid to use third party tasks. The only exception was the last task being an exploratory one, where the potential buyer wants to see the workings of a camera.

In order to assure that individuals act as in a complex decision-making process, they need a reason to undergo the effortful reflection and reasoning involved in a deliberative process. Motivation to reach valid (and good) decisions was manipulated by making all participants aware that their decisions would be recorded for further analysis, following the concept of "fear of invalidity", i.e., concern about a costly judgmental mistake (Fazio and Towless-Schwen 1999). Participants were also told that there was no time limit for them to reach a decision, so that they had the opportunity (no time pressure) to deliberate. Fazio and Towles-Schwen showed that "the reasoned-action process … involves individuals' 'computation' of attitudes toward the act by integrating their evaluations of relevant beliefs - occurs only when people are properly motivated and have the opportunity to pursue such effortful reflection" (1999, p.101).

The instructions for the tasks were presented on the top frame of the screen (Figure 57), and were worded in the same way irrespective of experimental condition. For example, the instructions for task 1:

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[64] Frokjaer, Hertzum et al. (2000) state that the measurement of effectiveness is often neglected on usability studies, because it is usually a challenge to develop a valid and reliable measure. Had this study chosen tasks based on participant's preferences, it would have created a difficult way to assess effectiveness.

Your friend, John, has a Kodak camera and you know he's happy with the brand (he says he likes the quality of the cameras and the results he obtains with them). The last time you met him, he mentioned being interested in buying his first digital camera and asked for your advice. His budget is £200 and he also asked you to be sure it was an easy to use, simple camera that produces good quality pictures. Which camera would you recommend to John? Can you offer him a second choice?

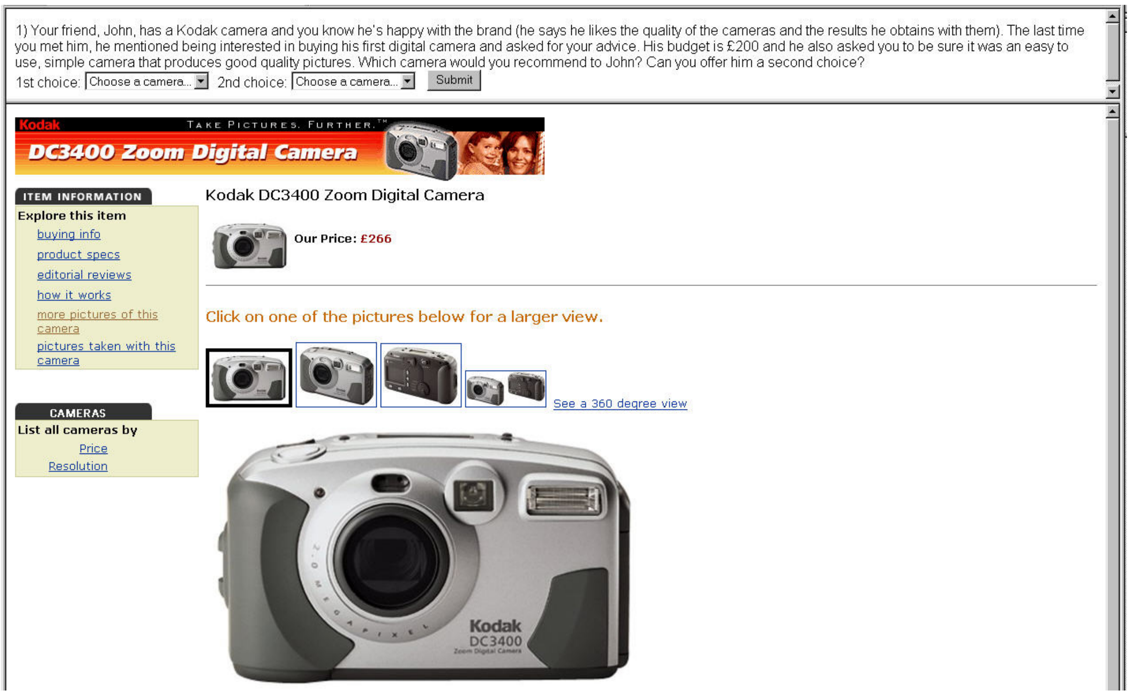

Figure 57 The current task is shown in the top frame

Next to the instructions, there was a drop-down menu (Figure 58) of all 11[65] cameras for both the first and second parts of the task ("1st choice" and "2nd choice" respectively). Thus, to complete the task, the user selects the cameras and click on submit to move to the next task, which is presented in the same manner. The instructions remained on screen during browsing. All participants worked alone, without any intervention or assistance from the experimenter.

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[65] The number of cameras reflects a typical consideration set size; in this case, cameras offered by one specific brand.

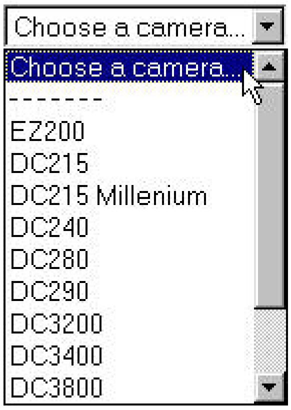


Figure 58 Drop-down menu for 1st and 2nd choice shown in Figure 57

The number of participants (40) and the number of tasks (5) produced a rich set of 200 cases from which the results are presented in the next section.

8.8 Results

ANOVAs (analyses of variance) and MANOVAs (multivariate analyses of variance) treat comparison tools and multimedia as between-subject factors. All hypothesis tests are directional, so all reported significance tests are one-tailed. P-values are significant if less than .05. Other values are considered not statistically significant. Where correlations are used, the Pearson correlation coefficient (*r*) is employed and interpreted as [.10–.29]:small correlation, [.30–.49]:medium and [.50–1.00]:large.

Summary of the Hypotheses

A summary of the hypotheses is included in this section to facilitate the understating of the results:

H1. **Decision Quality**: the presence of (a)IMPE and (b)CT will increase the quality of the decisions – measured by effectiveness, i.e., the score on decisions for the tasks;

H2. **Learning**: the presence of (a)IMPE and (b)CT will improve learning – measured by an incidental-learning test;

H3. **Time**: (a)The presence of IMPE will increase the time to reach a decision; (b)The presence of CT will reduce the time required to reach a decision – measured by total time spent on tasks;

H4. **Efficiency**: (a)The presence of IMPE will make the interaction *less* efficient - (b)The presence of CT will make the interaction *more* efficient – measured by dividing the number of correct recommendations by the total time spent on tasks;

H5. **Satisfaction**: The presence of (a)IMPE and (b)CT will make subjects feel more subjectively satisfied with the website – measured by a post-questionnaire;

H6. **Perceived ease of use**: the presence of (a)IMPE and (b)CT will make subjects perceive the tasks as being easier – measured by a post-questionnaire;

H7. **Naturalness/realness**: (a)The presence of IMPE will make subjects perceive the website as being more natural/closer to reality to interact with – measured by a post-questionnaire; (b) The presence of CT will *not* affect the way subjects perceive the website as being more or less natural/closer to reality to interact with – measured by a post-questionnaire;

H8. **Attitudes**: the presence of (a)IMPE and (b)CT will make subjects have stronger overall attitudes formed in relation to the website and the cameras – measured by attitude intensity in the post-questionnaire;

H9. **Beliefs' strength**: the presence of (a)IMPE and (b)CT will make subjects have stronger beliefs in relation to the cameras – measured by a post-questionnaire;

H10. **Perceived quality of decisions**: the presence of (a)IMPE and (b)CT will make subjects perceive their decisions as being of better quality – measured by a post-questionnaire;

H11. **Perceived knowledge**: The presence of (a)IMPE and (b)CT will make subjects perceive they have a better knowledge of the cameras – measured by a post-questionnaire.

8.8.1 Decision Quality

8.8.1.1 Overall decision quality

Decision quality is measured by the effectiveness of the decisions. A subject's effectiveness score is the number of correct decisions. Therefore the maximum possible score is 9 (see appendix B). For the tasks where a recommendation is asked (task n. 1 to 4), if the camera being recommended is correct, but is not in the right order (e.g., this particular camera should be the first choice, but it is suggested as a second choice), then it is considered as being half correct, contributing .5 point to the score. The expected choice decision is obtained by employing the weighted adding rule (Bettman, Luce et al. 1998) – this functions as a normative model that specifies how individuals can best make their choices. The tasks were formulated as to include a "dominant" alternative which is objectively better than any other in the choice set[66] (Haubl and Trifts 2000).

As an example of how decision quality was measured, consider Task 1:

Your friend, John, has a Kodak camera and you know he's happy with the brand (he says he likes the quality of the cameras and the results he obtains with them). The last time you met him, he mentioned being interested in buying his first digital camera and asked for your advice. His budget is £200 and he also asked you to be sure it was an easy to use, simple camera that produces good quality pictures. Which camera would you recommend to John? Can you offer him a second choice?

Using a non-compensatory lexicographic rule based on the first requirement, price, there are only three cameras in the set that cost less than £200: EZ200, DC3200 and DC215 (identified alternatives). Comparing these three cameras it is possible to see that the EZ200 is the cheapest, the simplest, the easiest to use, but at the same time the quality of the pictures is extremely poor compared to the other two. The DC3200 is cheaper and as easy to use as the DC215, but the DC215 produces much better pictures. So, the expected recommendations are the DC215 as first choice (best quality under £200), and the DC3200 as second choice (cheaper than the DC215). These recommendations will result in the score for this task to be two, one point for each choice. If the recommendations are DC215 and EZ200, than the score will be only one point. If the recommendations are DC3800 and DC215, for example, than the score will be only .5 point, since

[66] A dominant alternative is one that is equal to or better than all other alternatives on every attribute for a particular task. This provides a normative sense of the best choice regardless of the decision rule used.

the DC215 is been recommended as the second choice. If the recommendations are DC3200 and DC215 in this order, the score will be one point (half point for each one).

Considering the decision quality obtained in all tasks,

Figure 59 shows the average score on decisions for each of the 4 conditions. Figure 60 shows the scores obtained considering the conditions individually.

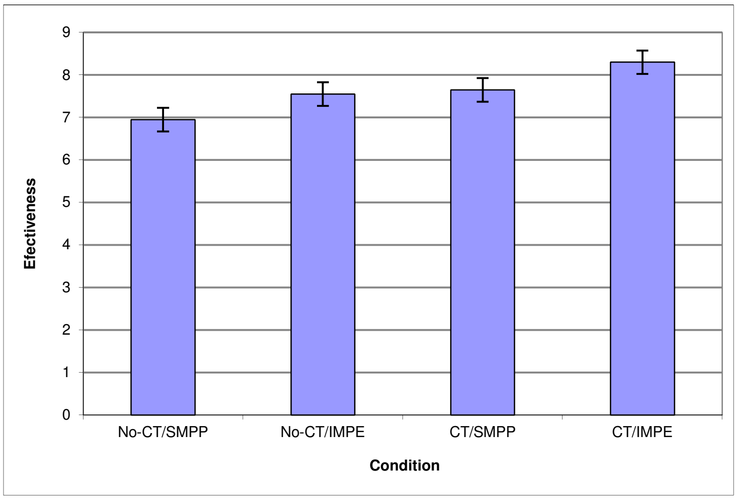


Figure 59 Mean score on effectiveness by condition

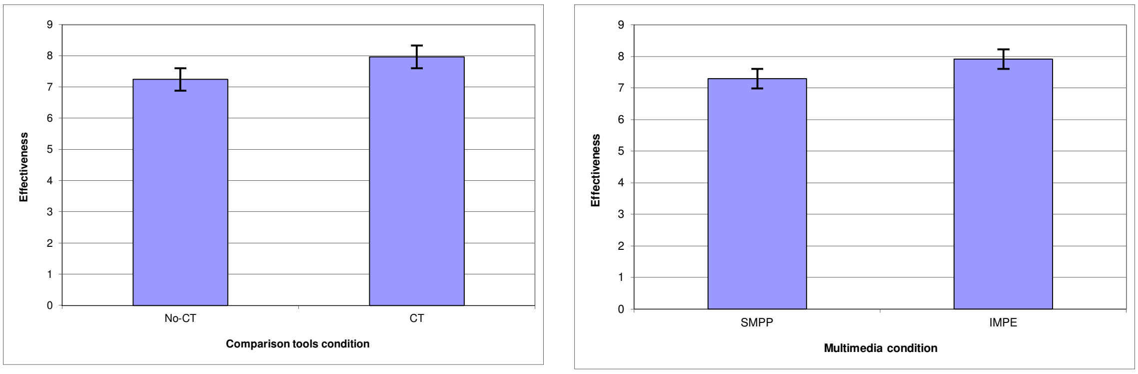


Figure 60 Mean score on effectiveness by condition

A two-way (MM x CT) ANOVA was performed to determine the effects of CT and MM on participants' decision quality. From the results, we can reject the null hypothesis. There was a significant main effect of multimedia on decision quality, $F(1, 36) = 3.34$, $p = .038$. Participants in the IMPE condition gave more accurate recommendations ($M = 7.92$, $SD = 1.127$) than did participants in the SMPP condition ($M = 7.30$, $SD = 1.10$). Hypothesis 1a is therefore supported.

The main effect of comparison tools is also significant, $F(1, 36) = 4.50$, $p = .020$. In general, participants in the CT condition made more accurate decisions ($M = 7.97$, $SD = .89$) than did participants in the No-CT condition ($M = 7.25$, $SD = 1.27$). This result supports hypothesis 1b.

The comparison tools x multimedia interaction was not significant, $F(1, 36) = 6.25E\text{-}03$, $p = .471$.

8.8.1.2 Correlations

No statistically significant relationship was observed between *e-commerce involvement* and score on recommendations ($r(38) = .25$, $p = .059$). A weak positive correlation was observed between *digital camera involvement* and score on recommendations ($r(38) = .27$, $p = .048$). Thus, digital camera involvement predicts 7.3% of the variation in score on recommendations in the sample. It is expected that part of the effectiveness on recommendations can be explained by involvement with digital camera; what this test reveals, though, is that this relationship is small and cannot be considered as the main factor on consumer behaviour (although the correlation was weak, an ANCOVA with digital camera involvement as covariate confirmed that involvement did not make any noise in the results for $p < .05$).

Another interesting possibility is that effectiveness is related to computer literacy and experience with the web. Nevertheless, there is no statistically significant relationship between *hours per week using a computer* and score on recommendations ($r(38) = -.095$, $p = .561$). There is also no relationship between *years of experience with computers* and score on recommendations ($r(38) = .158$, $p = .329$). A medium negative correlation was found between *years of experience with the web* and score on recommendations ($r(38) = -.312$, $p = .050$), predicting 9.7% of the variation on score on recommendations, but in the opposite direction of what would be expected, i.e., that more experience with web relates positively with effectiveness. Therefore, this makes the reliability of the test even stronger. *Frequency of access to the web* does not show statistically significant correlation: $r(38) = -.109$, $p = .501$. Similarly, no statistically significant correlation for *time spent on the Internet each time* ($r(38) = -.001$, $p = .997$). Experience with e-commerce (measured by *number of buying decisions using the web)* doesn't present any statistically significant relationship as well: $r(38) = .164$, $p = .311$.

It could be argued that simply spending more time to reach a decision would lead to a better score on recommendations. A statistically significant relationship was observed between total *time spent in tasks* and score on recommendations ($r(38) = -.520$, $p = .001$), but in the opposite direction to the hypothesis: subjects that spent less time performing the tasks, were more effective than the ones who spent more time.

8.8.2 Learning

One important measure in consumer behaviour is consumer learning. Learning was measured by an incidental test, i.e., an unannounced test (Appendix D), involving recall and recognition. It was administered after all tasks were completed. The reason for choosing incidental rather than intentional learning tasks was to capture the secondary and long-term implications of interactive product experience and comparison tools. If subjects were aware that one of the goals of the experiment was to test their memory and knowledge, they would have set their goals to perform optimally on these measures. In such a case, the relevance of these measures as an indication of future use would have been diminished (since they would reflect immediate and not long-term benefits). So if there is any difference in the learning test, we could infer that there was a change in the way participants processed the information.

The tests were marked by the experimenter, and scores were normalised in a 0 to 10 scale. Mean scores are shown in Table 17, Figure 61 and Figure 62

Table 17 Means of learning scores

		MM		
		SMPP	IMPE	*Row mean*
CT	No-CT	4.37	6.12	*5.25*
	CT	4.25	6.00	*5.12*
Column mean		*4.31*	*6.06*	

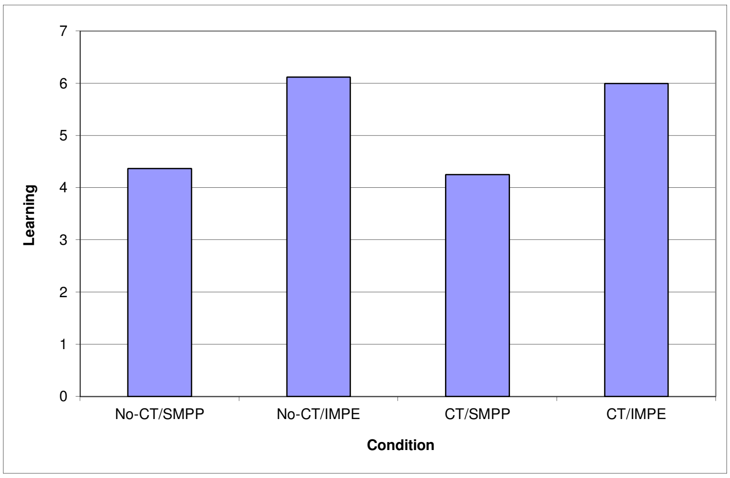
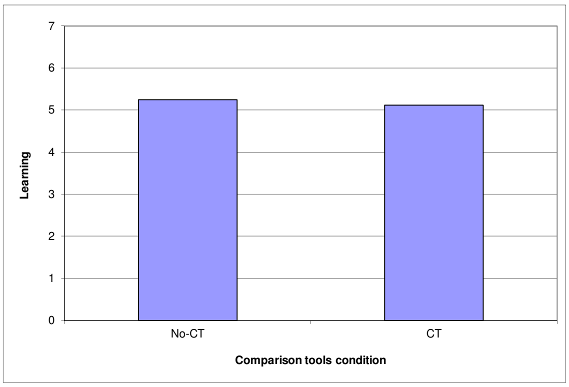


Figure 61 Mean score on learning by condition



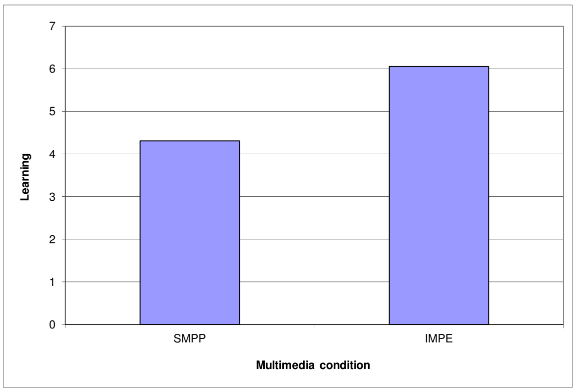


Figure 62 Mean score on learning by condition

There was no significant effect for CT, $F(1, 36) = .015$, $p = .452$, but MM, $F(1, 36) = 2.852$, $p = .05$ was statistically significant. Inspection revealed that participants in the IMPE conditions produced better outcomes in the learning test, as shown in Table 17. There was no significant effect for the interaction between CT and MM, $F(1, 36) < .001$, $p = .5$. Hence, hypothesis 2a is supported, and 2b, not supported.

8.8.2.1 Correlations

Park (1987) states that higher involvement has been shown to lead to greater information search. Thus, although precautions to avoid any interference were taken, there was a need to be sure that the scores on the learning test were not confounded by either involvement, both with digital cameras and e-shopping, and by time spent on tasks. Indeed, no significant correlation was found between learning test results and involvement: with e-shopping ($r(38) = .229$, $p = .155$), and with digital cameras ($r(38) = .230$, $p = .153$). Also, no statistically significant relationship was found with time spent on tasks: $r(38) = .029$, $p = .858$. Attitude towards digital cameras presents no correlation ($r(38) = .087$, $p = .592$), as does attitudes towards e-shopping ($r(38) = .009$, $p = .955$).

8.8.3 Time

To measure performance, end-to-end times were used, i.e., from the beginning of the first task to the end of the fifth and last[67] (Table 18). Subjects spent less time shopping if they were using comparison tools with static images and text. On the other extreme, the condition without comparison tools and with animations forced subjects to spend more time to perform the tasks (Figure 63).

Table 18 Means of total time in tasks (in minutes)

		MM		
		SMPP	IMPE	*Row mean*
CT	No-CT	20.495	26.945	*23.720*
	CT	16.083	18.233	*17.158*
Column mean		*18.289*	*22.589*	

An ANOVA on time spent on all tasks revealed that there was a significant main effect for comparison tools, $F(1, 36) = 7.52$, $p = .004$. As can be seen in Figure 63 and Figure 64, the presence of comparison tools reduced the time spent on tasks: participants with no comparison tools spent more time ($M = 23.72$, $SD = 9.46$) than participants with comparison tools ($M = 17.16$, $SD = 5.58$). Hypothesis 3b is supported.

As for the multimedia condition, there was a significant main effect, $F(1, 36) = 3.23$, $p = .040$). In general, participants in the IMPE condition spent more time ($M = 22.59$, $SD = 8.25$) than did participants with SMPP ($M = 18.29$, $SD = 8.09$). Hypothesis 3a is supported. The comparison tools x multimedia interaction was not significant, $F(1, 36) = .807$, $p = .187$.

[67] The following sub-sections show the analyses of the times for individual tasks, which, due to the different nature of each task reflect a more refined analysis.

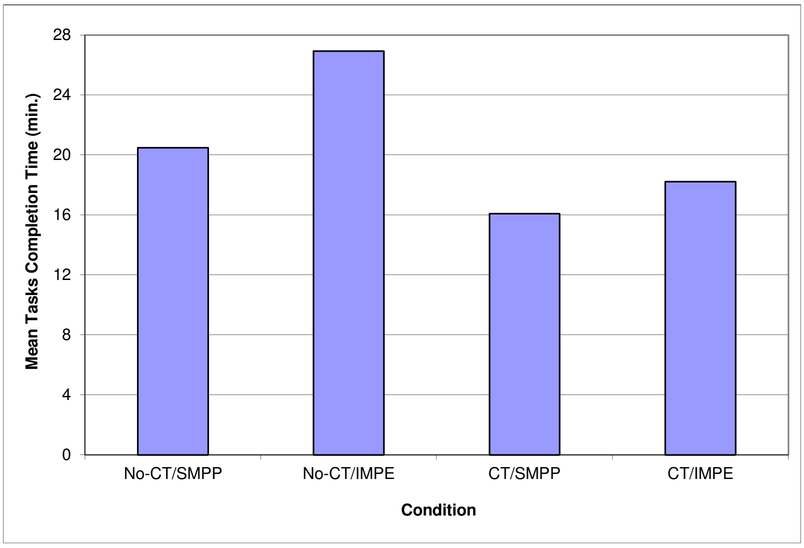


Figure 63 Overall completion time by condition

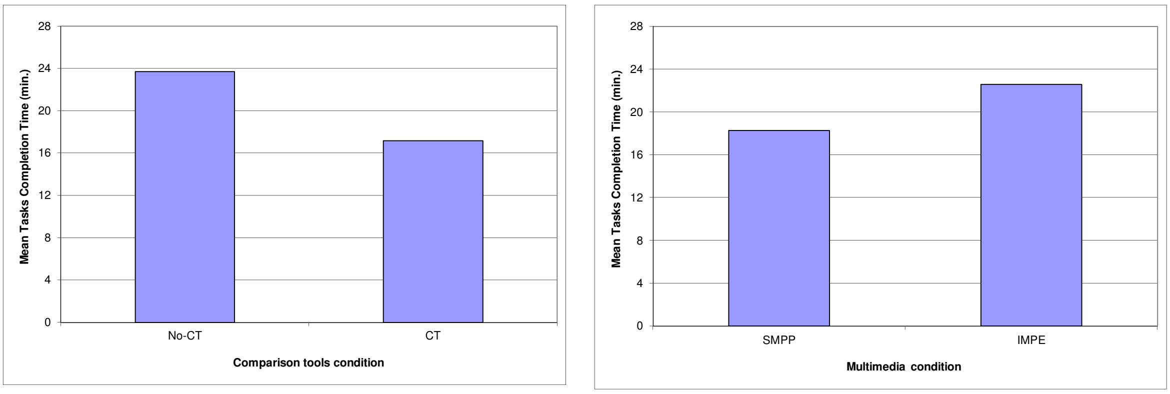


Figure 64 Overall completion time by condition

8.8.3.1.1 Analysing time spent on individual tasks

Since the tasks were designed to test different aspects of the interaction, it is important to analyse the results for each task. Each time measurement begins as the task is presented to the participant and ends when a decision is achieved, i.e., when the submit button is pressed. Average times spent on each task are shown in graphical form in Figure 65 and detailed in the following subsections.

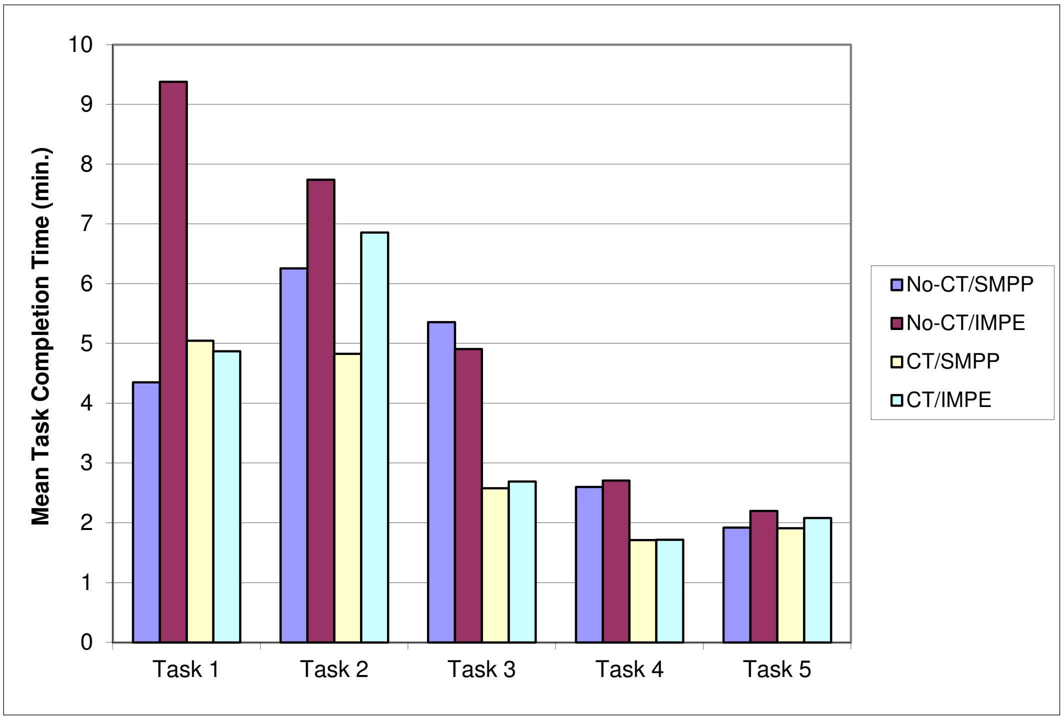


Figure 65 Individual tasks completion time by condition

8.8.3.1.2 Task 1

The multimedia factor for task 1 is significant (*F* = 5.383, *p* = .013); participants in the SMPP conditions spent less time (*M* = 4.70, *SD* = 2.19) than participants in the IMPE conditions (*M* = 7.13, *SD* = 4.63). The comparison tools factor (*F* = 3.298, *p* = .039) is also significant; participants in the No-CT condition spent more time (*M* = 6.86, *SD* = 4.73) than participants in the CT condition (*M* = 4.96, *SD* = 2.25). See Figure 66 and Figure 67.

The interaction between multimedia and comparison tools (Figure 68) produced a significant difference (*F* = 6.179, *p* = .009). In the IMPE/No-CT condition subjects spent more time in the animations checking that the cameras were easy to use. The fact that it was possible to interact with the cameras side-by-side in the IMPE/CT condition reduced significantly the time needed to compare the workings of the cameras.

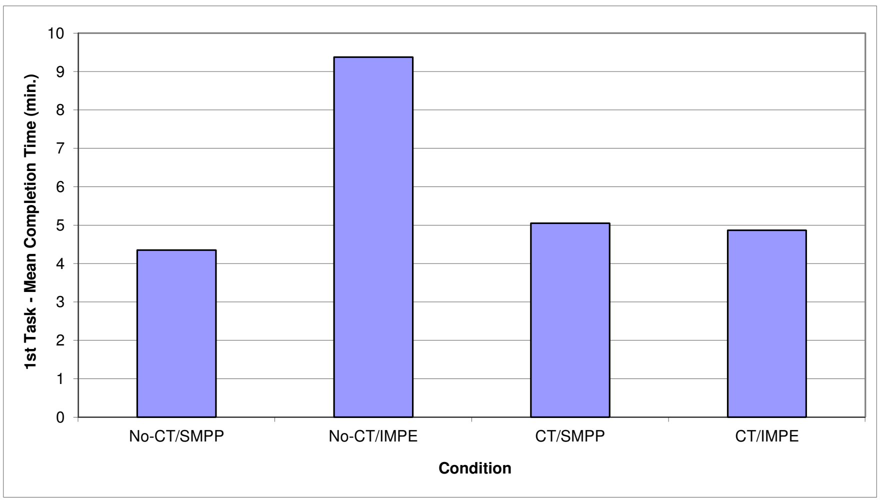


Figure 66 1st task - completion time by condition

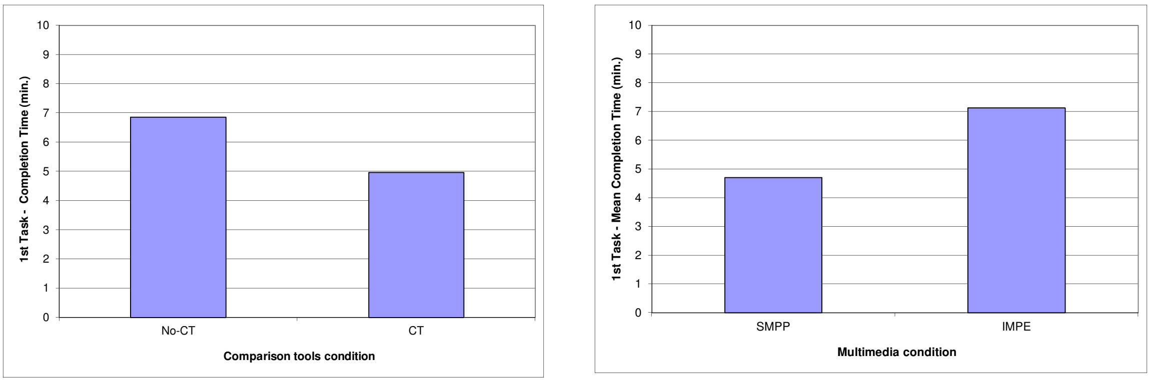


Figure 67 1st task - completion time by condition

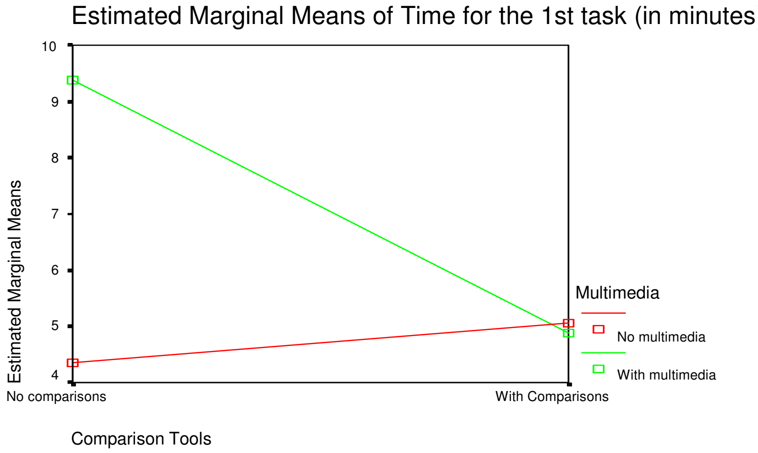


Figure 68 Interaction between CT and IMPE

8.8.3.1.3 Task 2

Figure 69 and Figure 70 show the mean times for the second task (mean=6.42min, *SD* = 2.66). Participants using IMPE spent more time on this task. The difference is significant (F = 4.78, p = .017). Comparison tools allowed participants to spend less time, since they could interact simultaneously with two animations; this difference in time, though, is not significant (F = 2.08, p = .078). There was no significant effect of interaction between CT and MM (F = .118, p = .366).

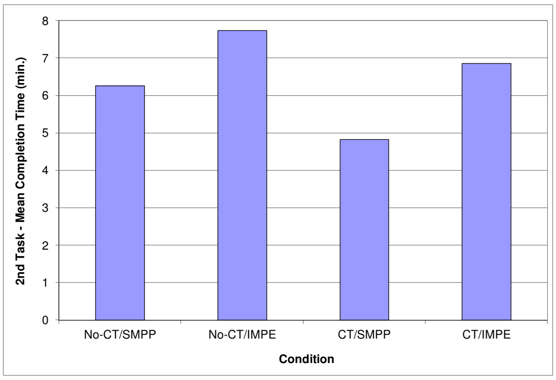


Figure 69 2nd task - completion time by condition

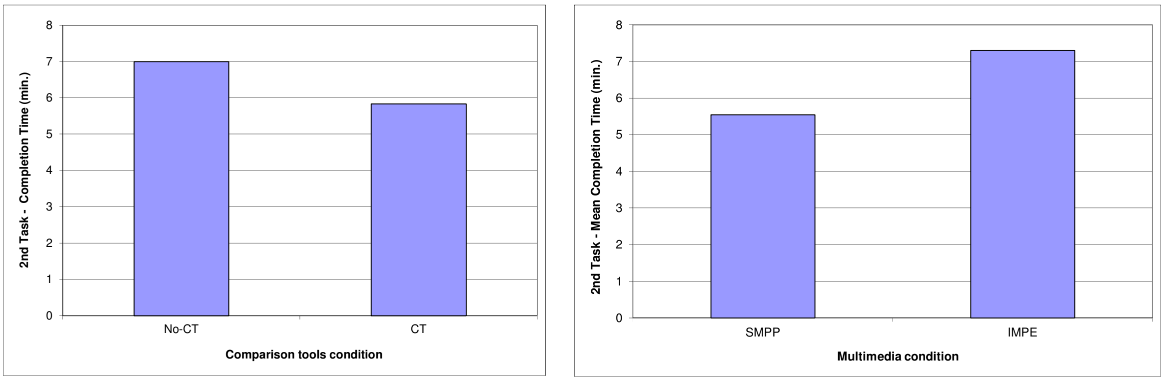


Figure 70 2nd task - completion time by condition

8.8.3.1.4 Task 3

Figure 71 and Figure 72 show the mean times for the 3rd task. Since in this task there is no need to interact with the animations, the main factor is CT, as can be seen in Figure 71. No-CT conditions present average time (M = 5.14, SD = 3.76), much higher than for the CT conditions (M = 2.64, SD = 1.09). A two-way ANOVA was performed. The presence of comparison tools is significant (F = 7.731, p = .004). There is no significant effect for multimedia (F = .035, p = .426) nor any significant interaction between comparison tools and multimedia (F = .099, p = .377).

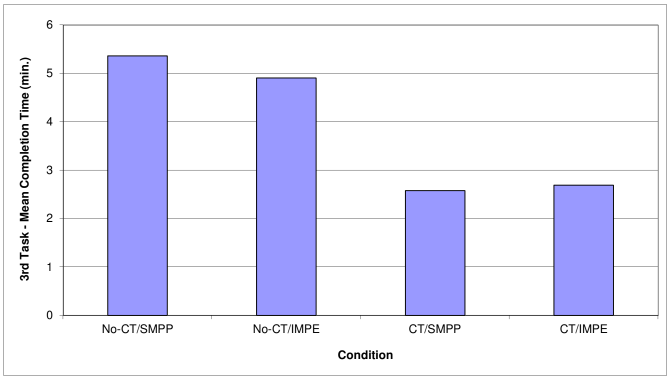


Figure 71 3rd task - completion time by condition

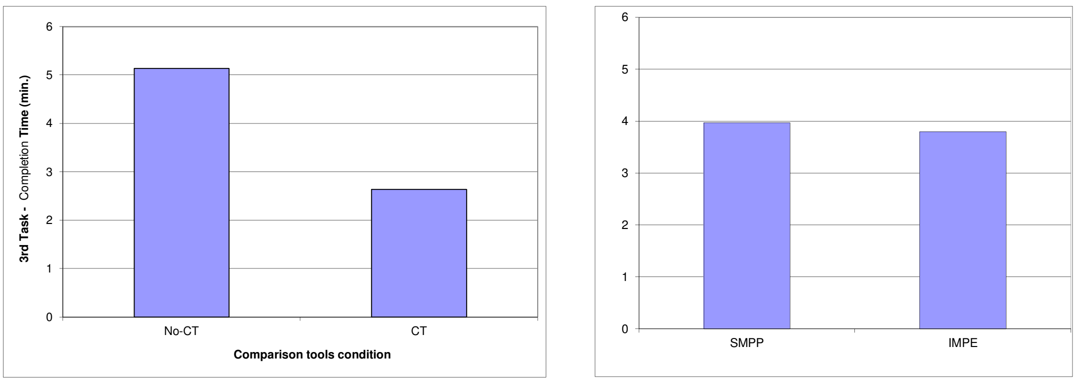


Figure 72 3rd task - completion time by condition

8.8.3.1.5 Task 4

Figure 73 and Figure 74 shows the mean times for the 4th task. Subjects in the CT conditions spent less time to perform this task. Like task 3, multimedia had no effect since there was no need for it

(F = .023, p = .440). CT was significant (F = 5.415, p = .013). The interaction between CT and IMPE didn't produce any significant effect (F = .016, p = .449).

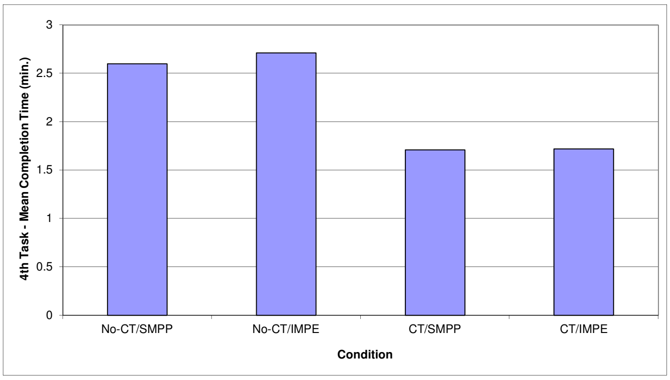
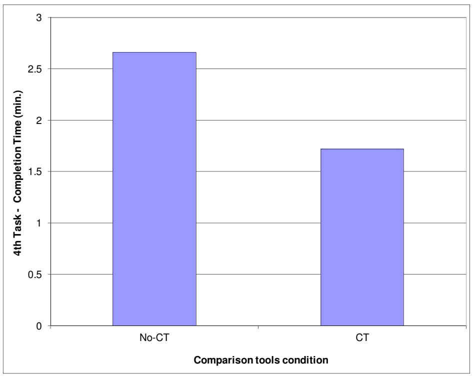


Figure 73 4th task - completion time by condition



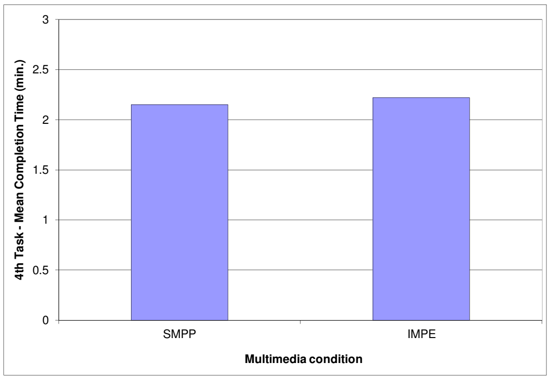


Figure 74 4th task - completion time by condition

8.8.3.1.6 Task 5

Figure 75 shows mean times for the 5th task. Since this task had to deal with the workings of one specific camera, there was no need for comparisons – there was no significant effect for CT (F = .06, p = .406). Subjects in the IMPE condition spent more time than the ones with SMPP, although not statistically significant (F = .73, p = .199). There was no significant effect for the interaction between CT and IMPE (F = .04, p = .421).

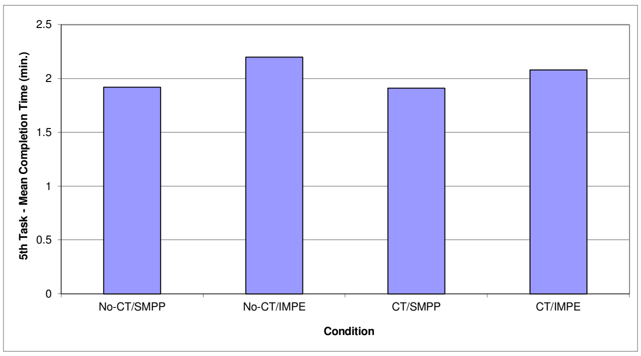
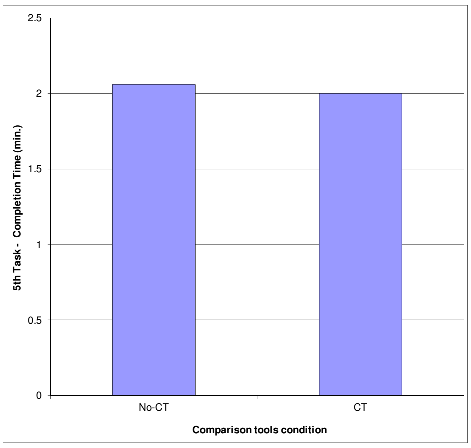


Figure 75 5th task - completion time by condition



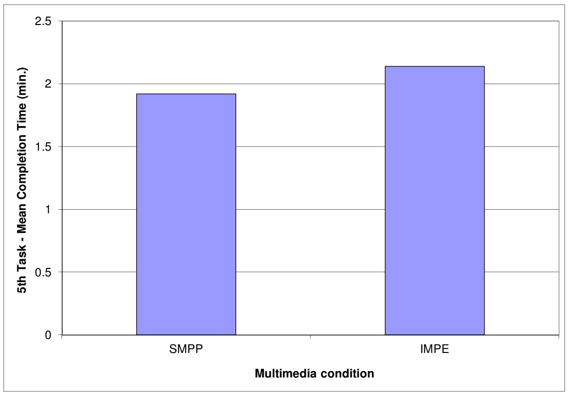


Figure 76 5th task - completion time by condition

8.8.4 Efficiency

In HCI, sometimes a particular variable has opposite effects on other measures (Landauer 1997), like, for example, decreasing time but increasing errors. In this study, it is possible to use the concept of user efficiency, computed as task effectiveness / task time (Bevan 1999).

In the previous sections it was shown that CT significantly reduced the time participants took to complete the 5 tasks. Participants in the IMPE conditions took more time to complete the tasks compared to the ones in the SMPP condition.

Figure 77 shows efficiency per condition. The presence of CT is statistically significant (F = 7.15, p = .005). Participants in the CT condition were more efficient (M = 862.89, SD = 311.73) than the ones in the No-CT condition (M = 604.88, SD = 296.62). Hypothesis 4b is supported.

As for IMPE, its presence is not significant (F = 1.75, p = .097). There was no significant effect for the CTxMM interaction (F = .02, p = .450). The fact that the MM does not affect efficiency significantly is an important finding. Even though participants in the IMPE condition took more time to complete the tasks, they were not less efficient than the ones in the SMPP condition. This can be explained by the fact that they were more effective, i.e., their decisions were more accurate. So, hypothesis 4a is not supported.

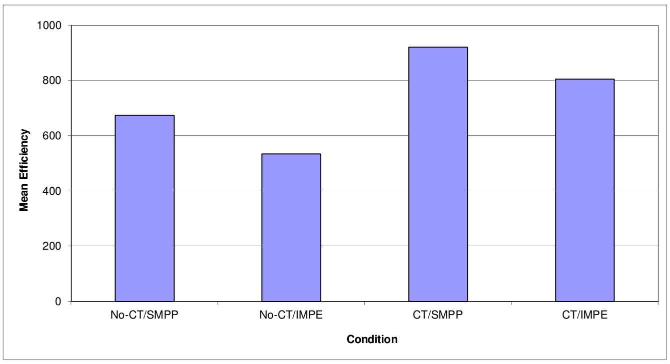
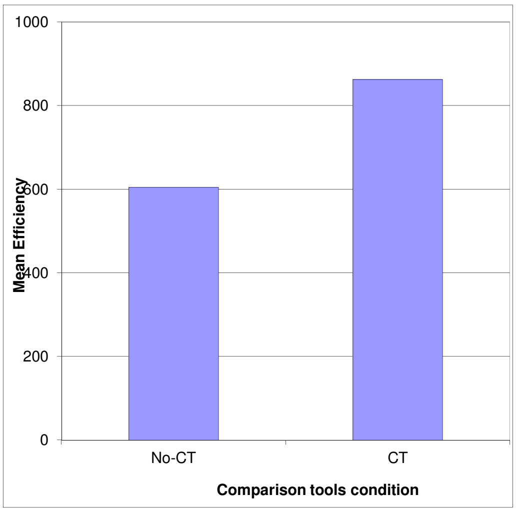


Figure 77 Overall mean efficiency by condition



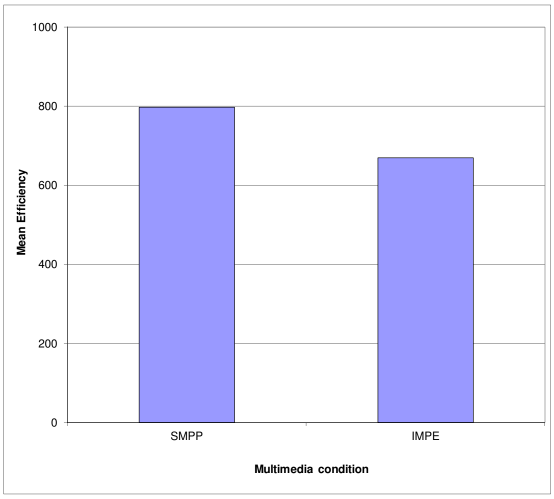


Figure 78 Overall mean efficiency by condition

8.8.5 Subjective measures

A variety of instruments are available for measuring user satisfaction and other subjective aspects. They include ASQ (Lewis 1995), CSUQ (Lewis 1995), PUEU (Davis 1989), PUTQ (Lin, Choong et al. 1997), QUIS (Chin, Diehl et al. 1988), SUMI (Kirakowski and Corbett 1988), and SUS (Brooke 1996). Some were developed specifically for the web: WebQual (Barnes and Vidgen 2002) and WAMMI (Kirakowski and Cierlik 1998; Kirakowski and Claridge 1998) while others measure specific aspects of e-shopping: trust (Jarvenpaa and Todd 1996) and trust and risk (Pavlou and Stewart 2000), or general consumer-behaviour aspects (Fazio and Zanna 1981; Klein 2003). While each instrument offers unique perspectives on subjective measures of software usability in general, of the web usability in particular or of consumer-behaviour perspective, for this study a customised instrument, based on existing instruments, was created, with seven sub-scales (Appendix C). They were all likert-scales with 7 points. Care was taken to reverse some of the codes.

A Cronbach alpha coefficient (whose theoretical maximum is defined as 1.00) of .80 was considered as a minimum reliability for the questionnaire as a whole – it reached .90. As for the sub-scales, a Cronbach alpha of .60 was accepted as minimum, especially because the number of items for each sub-scale was not too high (Nunnally and Bernstein 1994). As can be seen in Table 19, they all reached the minimum coefficient, except for the Beliefs sub-scale, which was dropped from further analyses.

Table 19 Reliability coefficients for the questionnaire

Component	Cronbach alpha	Number of items
Satisfaction (SAT)	.84	6
Perceived ease of use (EAS)	.78	8
Naturalness (NAT)	.79	4
Attitudes (ATT)	.61	6
Beliefs(BEL)	.47	6
Perceived quality of the decisions (QUA)	.68	5
Perceived knowledge (KNO)	.67	4
Total questionnaire (overall scale)	.90	39

The scores for the questionnaire are presented in Table 20. Each component is presented in one row. The scores for each of the seven sub-scales were calculated by averaging the responses (each sub-scale varied from 1 to 7).

Table 20 Mean score and standard deviation (inside brackets) for each sub-scale

Sub-scale	No-CT	CT	SMPP	IMPE
SAT	4.87 (1.19)	5.78 (.96)	4.78 (1.20)	5.87 (.84)
EAS	4.44 (1.03)	5.54 (.87)	4.69 (1.16)	5.29 (.96)
NAT	4.75 (1.06)	4.65 (1.27)	3.95 (.88)	5.45 (.89)
ATT	5.53 (.61)	5.84 (.50)	5.52 (.62)	5.85 (.48)
QUA	5.01 (.84)	5.58 (.80)	5.27 (.96)	5.32 (.78)
KNO	4.42 (1.16)	4.91 (.82)	4.587 (.90)	4.750 (1.15)

A composite MANOVA[68] (Table 21) shows the joint effect on the six components of the subjective questionnaire. Main multivariate effects are significant[69] for both comparison tools (F(7, 30) = 3.09, p = .008, η^2 = .374) and multimedia (F(7, 30) = 5.62, p < .001, η^2 = .521). No significant effect for the interaction between comparison tools and multimedia (F(7, 30) = .68, p = .334, η^2 = .116). Comparison tools account for about 37.4% of the variability in the subjective questionnaire, whereas multimedia accounts for approximately 52.1%. The observed power of the main effects of comparison tools and multimedia are high enough (.85 and .99 respectively) to assure a type II error is not made.

[68] In general, compared to individual ANOVAs, MANOVA can be a more powerful method to detect differences among groups if some of the responses are correlated (Bray and Maxwell 1985; Nunnally and Bernstein 1994; Yandell 1997; Harris 2011). In the case of this questionnaire, 10 out of the 15 correlations are significant (p < .005) and positive.

[69] The tests of significance are based on Wilks' lambda and Pillai-Barlett, because the former is historically the most widely used and the latter is considered the most robust (Bray and Maxwell 1985).

Table 21 MANOVA for the post-questionnaire

Effect		Value	F	Sig.	**Eta Squared** (η^2)	Observed Power
CT	Pillai's Trace	.374	3.09	.008	.374	.85
	Wilks' Lambda	.626	3.09	.008	.374	.85
IMPE	Pillai's Trace	.521	5.62	.000	.521	.99
	Wilks' Lambda	.479	5.62	.000	.521	.99
CT * IMPE	Pillai's Trace	.116	.68	.334	.116	.23
	Wilks' Lambda	.884	.68	.334	.116	.23

To test the assumption that for each group (each cell in the factor design matrix) the covariance matrix is similar, a Box's M test was run. Since M is not significant (M = 122.83, F = .92, p = .680), there is insufficient evidence that the covariance matrices differ. So, the assumption holds, and the MANOVA test is not invalidated[70].

As the overall multivariate test was significant, to further explain the group differences, follow-up analyses were conducted. The effects of each individual component are presented in Table 22, which shows the result of a two-way ANOVA for each component. As can be seen, the comparison tools effect is significant for general satisfaction ($F(1, 36) = 9.17$, $p = .002$), perceived ease of use ($F(1, 36) = 14.10$, $p < .001$), attitudes ($F(1, 36) = 3.18$, $p = .041$), perceived quality of decisions ($F(1, 36) = 4.61$, $p = .019$). The multimedia effect is significant for general satisfaction ($F(1, 36) = 13.25$, $p < .001$), perceived ease of use ($F(1, 36) = 4.33$, $p = .022$), naturalness ($F(1, 36) = 28.03$, $p<.001$), attitudes ($F(1, 36) = 3.54$, $p < .034$). The interaction between comparison and multimedia produces no significant effects.

[70] Box test was run for confirmation only since sample sizes are the same for the groups.

Table 22 Results of ANOVA tests on sub-scales

	SAT			EAS			NAT		
	MS	F(1,36)	Sig	MS	F(1,36)	Sig	MS	F(1,36)	Sig
CT	8.25	9.17	.002	11.96	14.10	<.001	<.001	.12	.363
IMPE	11.92	13.25	<.001	3.67	4.33	.220	22.50	28.03	<.001
CTxIMPE	.20	.22	.320	.48	.56	.229	.90	1.12	.148

	ATT			QUA			KNO		
	MS	F(1,36)	Sig	MS	F(1,36)	Sig	MS	F(1,36)	Sig
CT	.95	3.18	.041	3.25	4.61	.019	2.38	2.36	.066
IMPE	1.06	3.54	.034	.025	.03	.426	.264	.26	.306
CTxIMPE	.08	.28	.299	.081	.11	.368	2.14	2.12	.770

Figure 79 shows the **satisfaction** component for each of the 4 conditions. An ANOVA test found a significant effect due to CT, $F(1, 36) = 9.17$, $p = .002$ (higher satisfaction in the CT condition) and a significant effect due to IMPE, $F(1, 36) = 13.25$, p <. 0001. No effect was found for the interaction: $F(1, 36) = .22$, $p = .320$). Satisfaction and efficiency are not correlated: $r(38) = .058$, $p = .361$. Satisfaction and effectiveness are not correlated: $r(38) = .246$, $p = .063$.

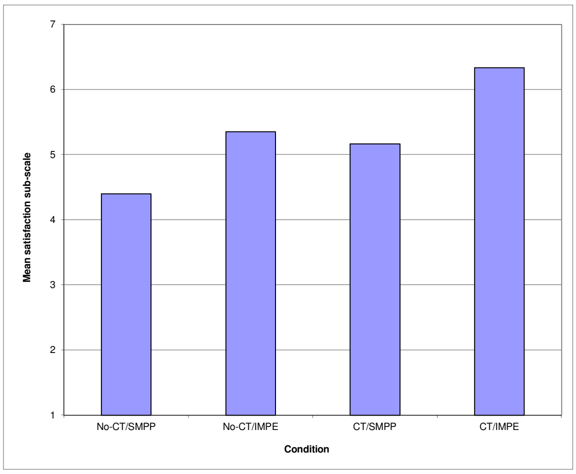
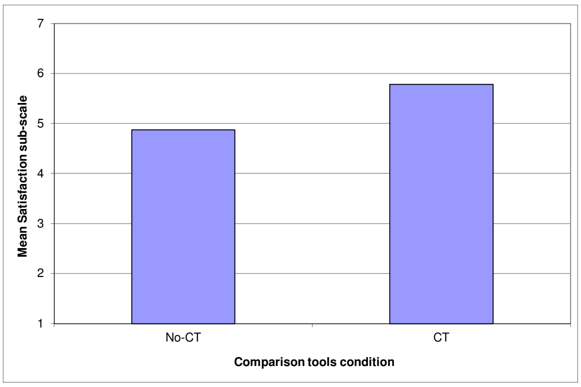


Figure 79 Mean score on satisfaction sub-scale by condition



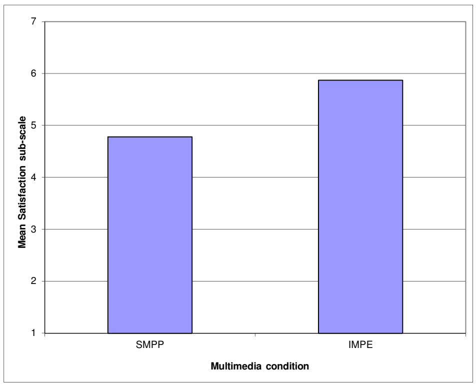


Figure 80 Mean score on satisfaction sub-scale by condition

Figure 81 shows the **perceived ease of use** component for each of the 4 conditions. It measures the facility experienced by the subjects in the decision process. An ANOVA test found a significant effect due to CT, $F(1, 36) = 14.10$, $p < .001$ (easier in the CT condition). However, IMPE did not have an effect $F(1, 36) = 4.33$, $p = .22$. Furthermore, no effect was found for the interaction: $F(1, 36) = .56$, $p = .229$.

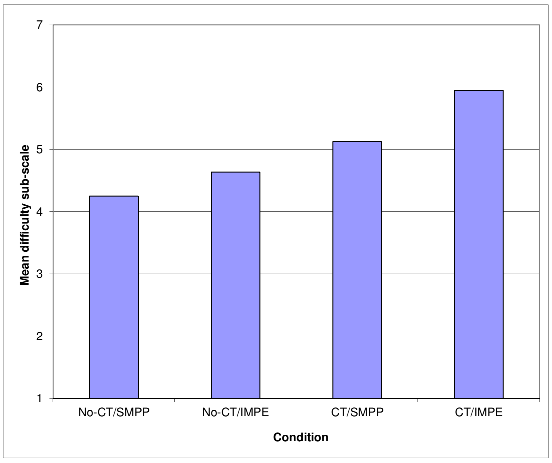


Figure 81 Mean score on perceived ease of use sub-scale by condition

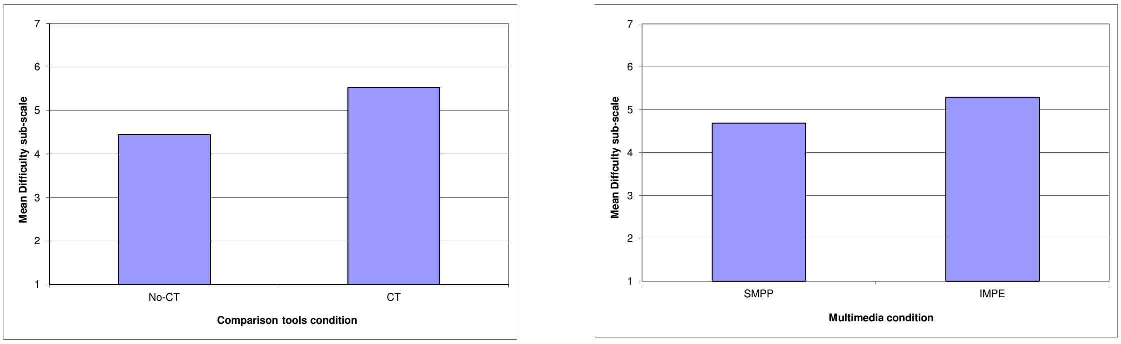


Figure 82 Mean perceived ease of use sub-scale by condition

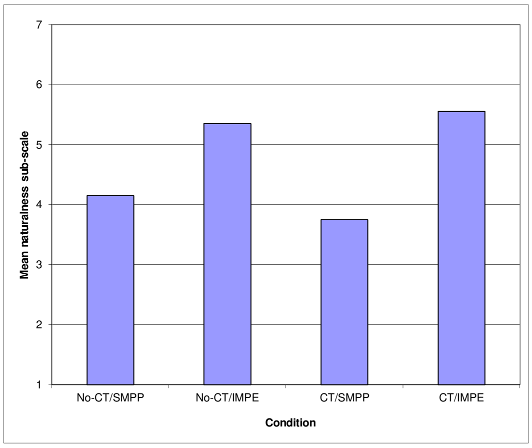


Figure 83 shows the **naturalness** component for each of the 4 conditions. It measures how the users felt about the naturalness and realness of the interaction. An ANOVA test found no significant effect due to CT, $F(1, 36) = .12$, $p = .363$. However, IMPE did have an effect $F(1, 36) = 28.03$, $p = <.001$. Furthermore, no effect was found for the interaction: $F(1, 36) = 1.12$, $p = .148$.

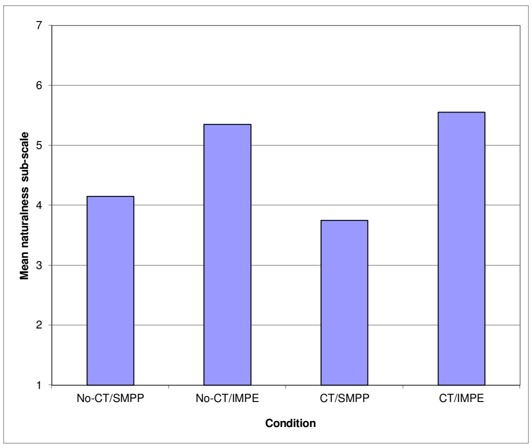


Figure 83 Mean naturalness sub-scale by condition

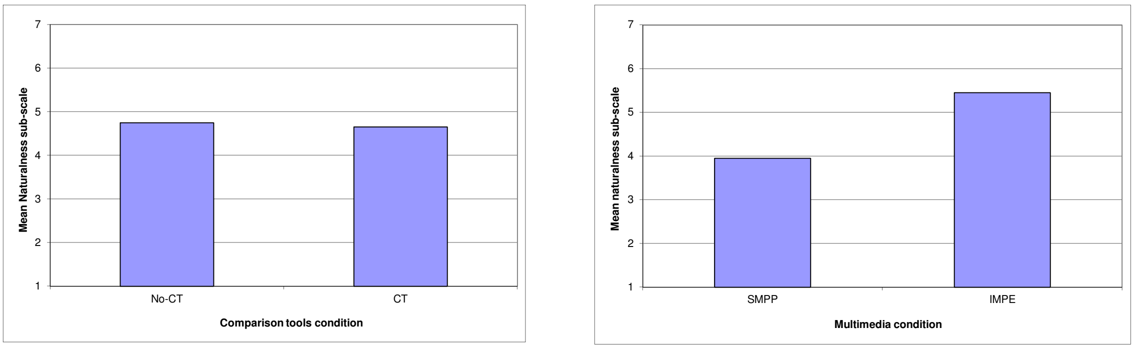


Figure 84 Mean naturalness sub-scale by condition

Figure 85 shows the **attitudes** component for each of the 4 conditions. An ANOVA test found a significant effect due to CT, $F(1, 36) = 3.18$, $p = .041$. IMPE also had an effect $F(1, 36) = 3.54$, $p = .034$. Furthermore, no effect was found for the interaction: $F(1, 36) = .28$, $p = .299$.

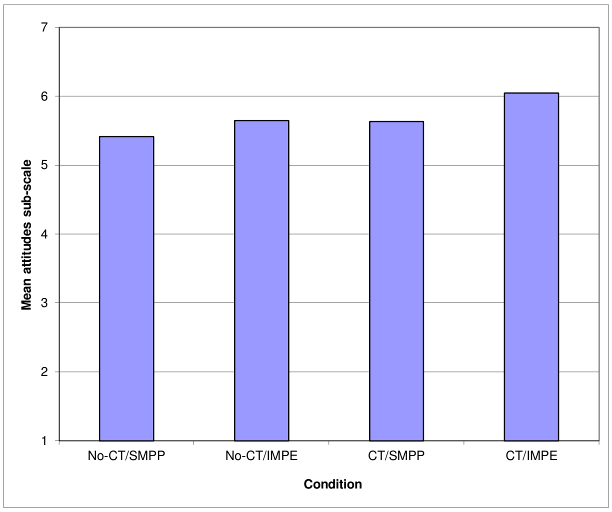


Figure 85 Mean attitudes sub-scale by condition

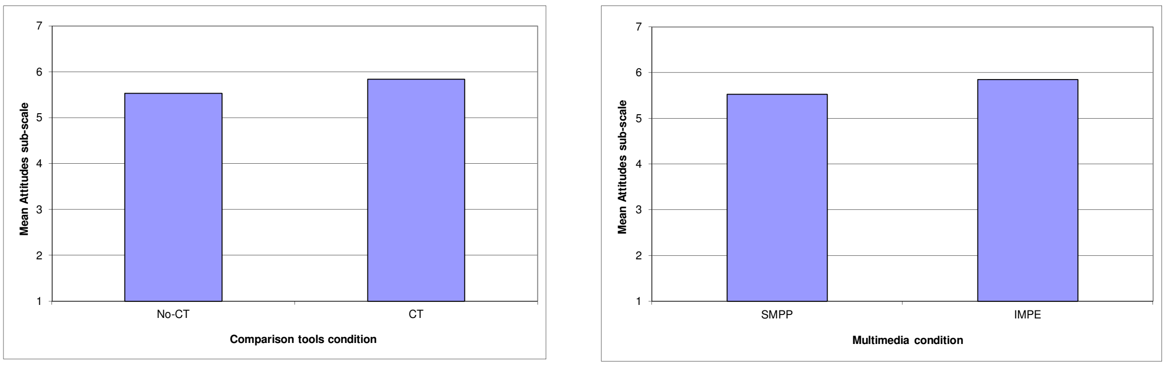


Figure 86 Mean attitudes sub-scale by condition

Figure 87 shows the **perceived quality of the decisions** component for each of the 4 conditions. An ANOVA test found a significant effect due to CT, $F(1, 36) = 4.61$, $p = .019$. IMPE had no significant effect $F(1, 36) = .03$, $p = .426$. No effect was found for the interaction: $F(1, 36) = .115$, $p = .368$.

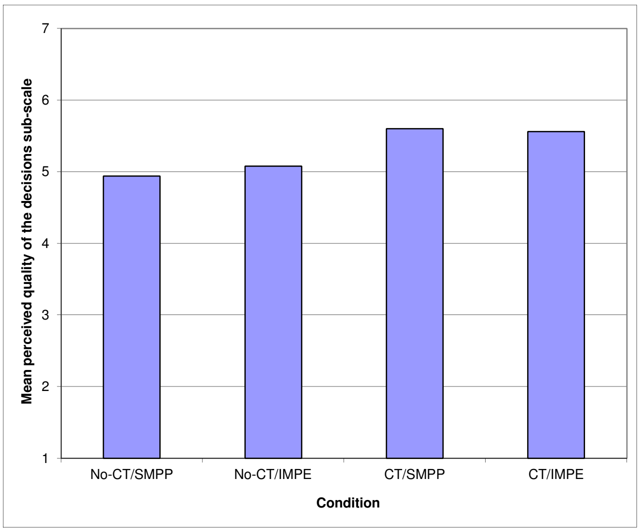


Figure 87 Mean perceived quality of the decisions sub-scale by condition

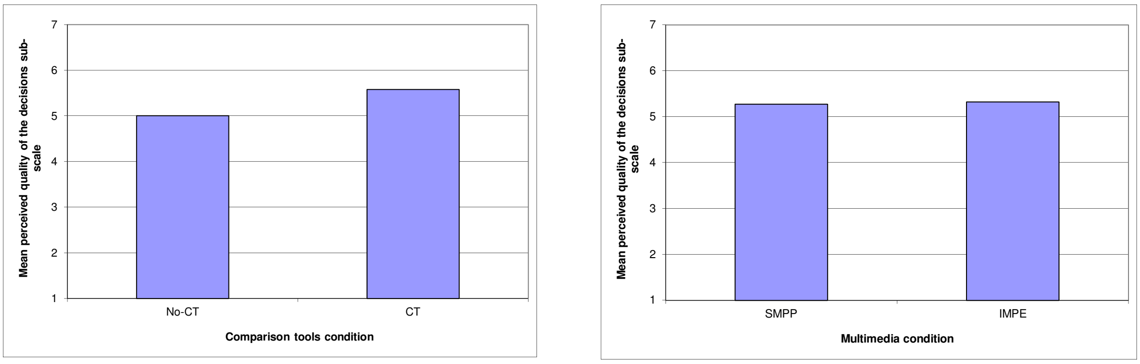


Figure 88 Mean perceived quality of the decisions sub-scale by condition

Figure 89 shows the **perceived knowledge about the cameras** component for each of the 4 conditions. This sub-scale was adapted from (Smith and Park 1992). An ANOVA test found no significant effect due to CT, $F(1, 36) = 2.36$, $p = .066$. Since p-value is close to .05, it could be considered as almost significant. IMPE also had no effect $F(1, 36) = .26$, $p = .306$. Furthermore, no effect was found for the interaction: $F(1, 36) = 2.12$, $p = .770$.

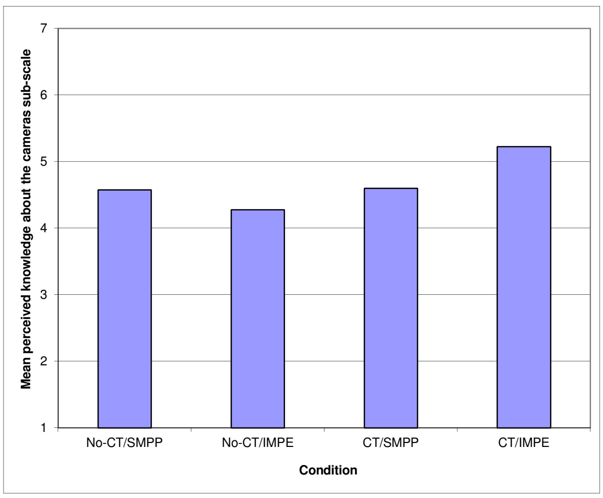
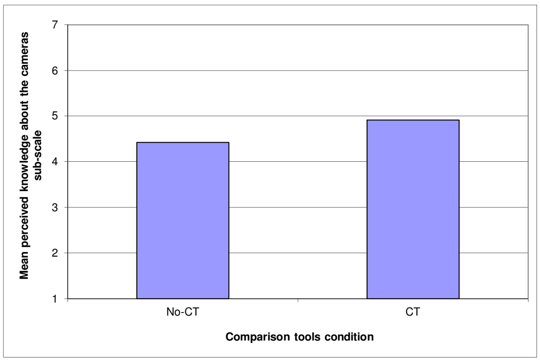


Figure 89 Mean perceived knowledge about the cameras sub-scale by condition



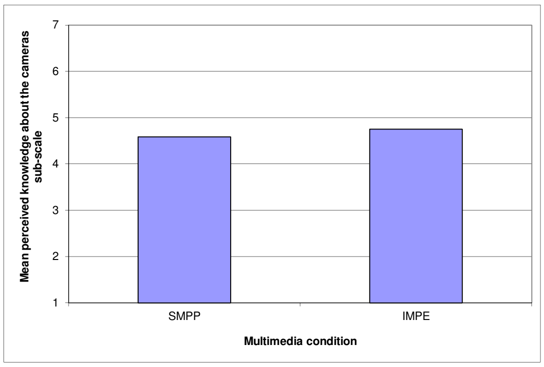


Figure 90 Mean perceived knowledge about the cameras sub-scale by condition

Hypotheses that are supported: 5a, 5b, 6a, 6b, 7a, 7b, 8a, 8b and 10b. Hypotheses that are not supported: 10a, 11a and 11b. These results are presented in what follows.

8.8.6 Analysis of the Open-ended Questions

In order to supplement the results and to reveal a more complete portrayal of the experiment, on the final questionnaire (Appendix E) participants provided responses to open-ended questions. The questions were designed to capture both negative and positive comments about their experience on using the e-shopping application, besides some general comments on e-shopping. A total of 509 comments were made. From those, 273 were either positive or negative (for questions 1 to 5), the remaining being neutral (corresponding to answers to questions 6 to 8).

The negative comments and suggestions for improvement were extracted from the combined answers to the following questions:

- What information would you like to see on this site that doesn't already exist?
- What tasks would you like to be able to perform with this site that you are currently unable to perform?
- What you didn't like? Any suggestions for improvement?

The positive comments were extracted from the combined answers to the following questions:

- What information/tool was most helpful? What part of this website do you find most interesting/useful?
- What did you like most?

The last question – Other Comments – provided both negative and positive comments.

An analysis of the comments about CT or MM from the 273 positive/negative comments revealed that[71]:

- In the No-CT condition, 85% of the participants made negative comments for not being able to make comparisons. The following are several typical comments:

'[I would like to]compare different cameras at the same time – in terms of specifications, resolution, size, appearance, price.'
'I'd like to see like-for-like comparison between two cameras.'

[71] The percentages of comments are reported as descriptive information.

'Compare different cameras at the same time – in terms of specifications, resolution, size, appearance, price.'
'It's difficult to compare pictures taken; difficult to compare list of specifications.'
'It was hard to compare cameras having to think backwards and forwards. So, being able to compare the specs on the same page would be useful.'
'Comparisons about price, specs, quality of pictures. If not possible side-by-side, it's difficult to choose.'

- In the CT condition:
  - No participant had a negative comment about comparison tools
  - 40% gave suggestions on how to improve comparisons

  What information would you like to see on this site that doesn't already exist?/What tasks would you like to be able to perform with this site that you are currently unable to perform?

To be able to compare more than 2 cameras
Pairwise – better way to select cameras
Choose more than 2 cameras to be compared
Comparison of more than two cameras at once
Being able to sort all specs, not just price and resolution
Compare more than 2 picture quality from 2 cameras (say show 4 pics taken from 4 different cameras)
Not being able to sort by all the different specs
The fact that you could only compare 2 cameras directly and not 3/more

  - 95% of the participants made positive comments about comparison tools
  - 70% made positive comments specifically about the comparison tables
  - What information/tool was most helpful? What part of this website do you find most interesting/useful?
  - What did you like most?

Table (full)
The full comparison chart
Feature lists (comparison tables)
Tables for comparison – sorted by resolution, price

  - 80% made positive comments specifically about the pairwise comparisons

Pairwise comparison between cameras was fairly easy – this was very useful
Comparing between pictures
The ability to directly compare 2 cameras and their respective picture quality and specs
Really liked the pairwise comparison
The full specification option, so could compare cameras
Comparing picture quality side-by-side

Comparison function – for comparing picture quality & how it works
Comparison of picture quality – increases confidence
Being able to compare the picture quality (the most important thing is the picture quality)

- In the SMPP condition, only 20% of the participants made a negative comment about the 'how-it-works' section

How-it-works not interactive
You can't really get a feel for how to use the cameras unless you try it yourself

- In the IMPE condition:
    - 20% of the participants gave negative comments about the 'how-it-works' section

How it works – slow (frustrating) – it's not as real as the real cameras, but it's better than not having
Don't make me sit through animations – should be able to speed them up with this site that you are currently unable to perform)

-
    - 35% gave suggestions on how to improve the IMPE

How-it-works – could be closer to the real thing (What you didn't like? Any suggestions for improvement?)
More freedom in the how it works (closer to reality) (What tasks would you like to be able to perform)

-
    - 75% of the participants made positive comments about the 'how-it-works' section

Hot it works – can try out before buying (What information/tool was most helpful? What part of this website do you find most interesting/useful?)
How it works – you can see before buying how easy it is to use
How it works – better understanding of the camera
How it works – learn how it works before buying
How it works - interacting with the web make the user feel like it is real
How the cameras works – interacting with the product
How it works – informative (good before buying it)
Explaining how to use the camera was most interesting

-
    - What did you like most?

The demos on how to use the camera – this is more conclusive than being shown by a salesman
Seeing how the camera works – nice to see the setup (if it's easy to setup)
How it works

Interaction with the camera
How the camera works
Demonstration of how to use the camera – before buying it's good to have the feeling of the camera
The way the site showed how to use each camera both individually and providing a comparison

By analysing the comments, we can see that CT are missed when not present. When present, they are seen as very important for making decisions. On the other hand, IMPE is mostly valued when present, but not missed when absent. This could be because SMPPs are perceived as giving enough detailed information about the workings of the products, and/or because consumers have lower expectations for e-shopping designs, i.e., they are used to not having interactive product demonstrations. An observation such as "*it's not as real as the real cameras, but it's better than not having*" sums up the concept of multimedia experience: it is not a replacement of the real thing, but it has its own role in a decision making process.

The next Chapter discusses the results presented in this Chapter.

Chapter 9 Discussion and Implications

"Science and everyday life cannot and should not be separated"

Rosalind Franklin

9.1 Introduction

In the previous chapter, empirical work concerning the effects of multimedia and comparison tools on consumer decision-making was described. The study stands out from previous ones in this area through its emphasis in three aspects. First, it uses a consumer choice model in contrast with preference models used in marketing/advertising research. Second, it presents both experience and search product attributes in a realistic way. Third, the amount of information about the products is kept constant in all conditions. The results of the aforementioned experiment were presented and analysed.

This chapter discusses and interprets these results considering the theoretical aspects raised in previous chapters. Results were obtained from objective and subjective data, questionnaire and open-ended questions. Furthermore, these results are interpreted in light of past research and theories. Where appropriate, the findings are also contrasted to those of the survey described in Chapter 5. In terms of structure, this chapter is organised following the experimental hypotheses presented in Chapter 6, where each hypothesis is individually examined. Next the main effects of interactive multimedia product experience (IMPE) and comparison tools (CT) are summarised. Finally, the chapter concludes with limitations and implications of these results.

The results of this study indicate that IMPE and CT have strong effects on online consumer behaviour. Table 23 provides a summary of the results of the study. For the most part, results matched the expectations; with some exceptions, hypotheses were tested and not rejected. As already mentioned in Chapter 6, beliefs strength has not reached the minimum Cronbach alpha coefficient. For this reason, it will not be discussed in this chapter.

Table 23 Summary of results

	Hypothesis	(a) MM	(b) CT
H1	Decision quality	S	S
H2	Learning	S	NS
H3	Time	S	S
H4	Efficiency	PS	S
H5	Satisfaction	S	S
H6	Perceived ease of use	S	S
H7	Naturalness / realness	S	S
H8	Attitudes	S	S
H9	Beliefs strength	NA	NA
H10	Perceived quality of decisions	NS	S
H11	Perceived knowledge	NS	PS
	S: supported, PS: partially supported, NS: not supported, NA: not possible to analyse[72].		

[72] Not possible to analyse as the sub-questionnaire did not reach an acceptable level of reliability.

9.2 Decision Quality

The results of the study relative to the quality of decision making indicate that both CT and MM lead to better decisions.

Theoretically, comparison of alternatives shifts the decision-making from a memory-based to a stimulus-based choice (Alba, Lynch et al. 1997), which enhances the precision of the decision process and therefore the optimality of the ultimate decision. The results from the current study confirm these predictions. It is less important for the consumer to remember specific pieces of attribute information about products, and he/she can concentrate on the task-at-hand. Without CT, the user can only perform alternative processing. When CT are present, they offer the possibility of both alternative and attribute processing, which require less cognitive demands on memory and attention.

However, Alba, Lynch et al. (1997) prediction is entirely based on search attributes. There is no comparison of experience attributes in their work. The results from this thesis show that it is also valid for experience attributes, i.e., the support for comparisons of experience attributes improves the quality of decisions.

Regarding multimedia experience, the only partially comparable study was done by Li, Daugherty et al. (2003), because they supposedly measure quality of the decisions relative to the use of multimedia presentations. In this respect, it shows similar effects, i.e., that a mediated product experience that better support consumer's tasks produces better decision quality. However, even though the authors use the term decision quality, actually what they measure is confidence in buying, since there is no product choice (participants were only presented with one product and asked if they were confident in making a purchase decision). This means that it is difficult to compare the findings on decision quality with other studies, as they did not use a choice model.

If multimedia product experience is in fact positioned between indirect and direct experiences, some of the effects obtained by direct experiences can be expected. Since one of the effects of direct experience is improved decision-making for experience products (Jones and Fazio 2008), it can be seen that multimedia experience is closer to direct experience than indirect experience, at least in this respect.

9.3 Learnability

Learnability measures how closely the costumer remembers the details of the products later on. Participants in the CT condition were expected to perform better in the incidental learning test compared to participants in the No-CT condition. This hypothesis was not supported. Although Alba, Lynch et al. (1997) predicted that the comparison of alternatives would inspire consumers to learn more during the decision-making process, this hypothesis was tested and rejected. This may be because CT make decision-making more efficient, which means consumers visit fewer products and spend less time examining products. Consumers will find product information organised in tables and compared to several alternatives meaning that part of the buying decision can be made without the need to examine details of the products.

The IMPE proved to affect learning positively, as was expected. The improvement it produced on learning was quite remarkable: 40% for the No-CT conditions and 41.20% for the CT conditions.

The results for the learning test clearly indicate that IMPE lead to a greater retention of information about the cameras. Because the amount of information about the cameras provided by the "how-it-works" section was constant in all conditions, it appears that the interactive animations provide an additional source of recall and recognition. This conclusion is consistent with the idea that multimedia increases the distinctiveness of a stimulus, thereby facilitating learning processes by increasing the accessibility of the stimulus in memory.

Since for all conditions learning test was incidental (participants did not know they would be tested after using the website), it is possible to suggest that IMPE engaged participants in processing information that was more conducive to learning. It seems that subjects using interactive animations process the "how-it-works" section in a more meaningful and deeper way.

One of the characteristics found in educational multimedia is that learning appears to improve when the learning task encourages the learner to actively process and integrate the information (Najjar 2001). This is based on the fact that these tasks may cause users to focus their attention on the information and cause them to process the information more elaboratively. Alty (1991) adds that elaboration can be thought of as an encoding process that enriches a stimulus, integrating the information with prior knowledge, and increasing the number of interconnections it has with other information. This appears to be especially true when the processing focuses on the meaning of the information rather than its appearance (Craik 2002), and when the processing integrates the information being studied. Information that is processed in this way may become easier to connect with long-term memories, may improve retrieval, and may therefore result in improved learning (Najjar 2001). Baddeley (1997) states that some form of semantic processing happens when the learner elaborates the information. Several studies (Baddeley 1997; Craik 2002) support the idea that semantic processing improves learning.

Although this is not exclusive to multimedia, in the case of the experiment in this thesis, the tasks are not built with the explicit intention of learning - they are common shopping tasks. Moreover, the learning test is incidental – participants were not told they would face a learning test after completing the tasks, so they were not "studying" the materials with the intention of learning as much as possible; they were learning by doing.

Comparing the two types of representations used – static pictures and interactive animations – it is possible to find several similarities between them as explained in Chapter 4. However, in the case of digital cameras, the underlying properties of the functional inspection task are mainly dynamic, and in this case interactive animations were superior in terms of learning, i.e., the media used supports the task more fully. Animations and pictures impose different cognitive demands on the learner when creating a mental representation of the dynamic learning content. It seems that animations offer a more complete model for the generation of a mental representation of motion, which consequently supports deeper understanding and learning than static visuals do (Lewalter 2003). On the other hand, the use of static pictures to describe a dynamic and interactive procedure forces users to infer the model on their own. Thus, the main argument for the learning superiority of interactive animations in this study is not the media superiority, but the match between information type, task and media.

The interactive aspect is important to make users act and direct the demos. Processing the information in an active way helps users to make sense of it, which improves memory performance. According to the levels of processing theory of memory (Liao 1999; Craik 2002), the deeper the processing of information during learning, the more it will be retained and remembered. Interaction, in this case, provides support for users to process information and to construct meaning. Animations that are not interactive tend to reduce cognitive load, but at the same time may prevent important cognitive processing for deep understanding.

9.4 Time and efficiency

It is not surprising that participants in the CT conditions completed the tasks more quickly than participants in the No-CT conditions. It is much more efficient to evaluate alternative products if they are presented in tables of comparisons, than if they are presented as a list of products (Alba, Lynch et al. 1997). In this respect, these results agree with Haubl and Trifts (2000) findings. This can be explained by the fact that with CT the presentation format is congruent with the decision strategy. By being able to select a strategy that requires less effort reduces the time costs involved in the decision making process.

Apart from the fact that many decisions can be based entirely on the comparison table, a second and more important consequence of CT is that the number of products for which detailed information is inspected is significantly reduced as predicted by a non-compensatory decision strategy. Decision time is, consequently, contingent on the presence of CT, reducing dramatically the time it takes to reach a decision, hence reducing the cognitive effort involved in the decision[73].

In terms of efficiency, CT contribute not only to the reduction in the time to take a decision, but also in improving the quality of the decisions. This is valid for comparisons of both search and experience attributes. The interaction between time and quality of decisions is not always straightforward: one would think that when a user spends more time to take decisions, his/her decisions will be more effective. The use of CT shows that the way information is presented affect efficiency significantly. To reach the same level of quality in the decisions taken, consumers with no comparison tools would have to spend significantly more time before making the decisions. However, this happens up to a certain point, until the user realises that the cost of exerting cognitive effort exceeds the benefits of minimising errors (Payne, Bettman et al. 1993).

With respect to multimedia, results confirmed that IMPE makes consumers spend more time to reach a decision. This can be explained by two contributing factors: first, interacting with the cameras is more time consuming than simply seeing static pictures, and second, interactive animations engage users in exploring the cameras in more detail. In a preference model study of products presentation using static pictures compared to 3D virtual presentations (Suh and Lee 2005), the latter also took more time for participants to interact with (in fact, three times more on average).

The interactive animations require the user to act (e.g., make decisions on what to do next) in order to access the information, which potentially increases the complexity of the interaction, and by consequence affects the time required to access content. However, as McMillan and Hwang (2002) conclude, “time spent controlling the system is not always related to complexity; increased time can also be a result of intense engagement” (p. 34). Based on the comments provided by participants in the experiment, 75% of the ones in the IMPE condition felt the product demos were the most interesting and useful part of the website. This result allows us to speculate that participants became more engaged in this condition.

The fact that it takes more time to interact with IMPE cannot be underestimated. However, as the results show, consumers do spend more time, but also make better decisions; so they are no less efficient. The added time is in fact needed to learn about experience attributes and would not be so noticeable for search products (Huang, Lurie et al. 2009).

The high variability among participants in the same condition, can be explained by differences in perceived risk, i.e., for some the acceptable level of perceived risk is reached faster than for others, who take more time to take a decision. This would require further investigation.

[73] Decision time is commonly used as a surrogate for cognitive effort in decision making research area (e.g., Jarvenpaa (1989)).

9.5 Satisfaction

Comparison tools affected satisfaction in a positive way. This is in line with the theoretical prediction by Alba et al (1997) who state that consumers are more satisfied with the shopping experience when they can compare product alternatives. The main reason for this is that, when information is organised in a matrix, both alternative and attribute processing take place. Consequently the consumer is able to process the information following his/her own strategy, and not a strategy pre-determined by the designer and/or seller. Furthermore, comparison tools reduce the cognitive demands on consumers.

In addition to tables of attributes, the ability to compare the functionality of products and their performance also contributes to consumer satisfaction as it supports a typical consumer activity.

The higher satisfaction reported by participants in IMPE conditions compared with the SMPP conditions is in agreement with the notion that multimedia product experience place the consumer closer to the product, making evaluation more natural, as if he/she was diagnosing the real product. In the SMPP conditions, participants only saw static pictures of the camera in “action”, making evaluation a less satisfactory experience. This is a typical case in which the dissonance between task (evaluation of a product), type of information (procedural) and type of media (static pictures or interactive animations) is reflected on the satisfaction that users have with the experience. It shows that media allocation and exploration play a central role on user’s satisfaction. The possibility of exploring a representation of the product makes the whole experience more in tune with consumer’s expectations.

9.6 Perceived ease of use

Although perceived ease of use is acknowledged as fundamental for user acceptance of technology (Reinicke and Marakas 2005), very little emphasis is given to it (Venkatesh and Davis 2000). It is even more important, as we consider that many people do not shop on the web because they consider it to be difficult (Shih 2004). This is recognised by information systems theories such as the Technology Acceptance Model (TAM) (Davis 1989) that suggests a number of factors that influence the decision of how and when users will use the technology. The main components of the theory are perceived usefulness (in the present work more related to the perception of the quality of the decisions) and perceived ease of use, which is related to the perceived level of effort to use the system (Morris and Dillon 1997; Shih 2004). TAM considers that both perceived usefulness and perceived ease of use contribute to attitude toward use, intention to use, and actual use of technology - even its critics acknowledge its value (Bagozzi 2007). The theory states that, given two technologies with similar levels of usefulness, the one that is perceived to be easier to use by the user, has a better chance of being accepted and used (Morris and Dillon 1997; Schepers and Wetzels 2007).

In the experiment, both IMPE and CT had a positive impact in perceived ease of use. If it is easier to evaluate experience attributes through direct experience compared to indirect experience, a similar effect happens with multimedia product experience as shown in this study. However it is through the open-ended questionnaire that we can examine participants’ perception of MPE: 75% made positive opinions of the tool which was more supportive of their evaluation tasks than its static counterpart of pictures and text (open-ended questions are discussed in Section 9.13).

9.7 Naturalness/realness

One of the purposes of a multimedia product experience is to create a sense of presence, not in the strict sense of “being there” as defined by Steuer (1992) - the experience established “in an environment by means of a communication medium" (p. 76) - but more like bringing the objects closer, making it possible to indirectly meet and experience objects.

The naturalness and realness feature suggests that it is possible to make multimedia interaction look more real. It is no surprise that naturalness has been identified as a component of presence (Lessiter, Freeman et al. 2000). If the interaction achieves naturalness in an electronic-shopping environment, consumers can feel closer to the product. The combination of naturalness and realness can create a perceived sense that is generated from sensory input, mental processes, and past experiences assimilated together in a current state (Gibson 1966).

The interactive multimedia product experience uses a model of product that represents both physical and behavioural properties. This is perceived by users who identify IMPE as being more natural and realistic, as the object can be explored in a more realistic way.

As expected, CT do not affect naturalness and realness, and no difference was observed.

9.8 Attitudes

Both IMPE and CT have a positive effect on positive attitudes formed towards the shopping experience and the products. Attitudes seem to have an impact on consumer confidence, which is expected to influence behaviour: the more positive attitudes, the more inclined the consumer becomes to shop online as he/she feels more confident (Lee, Hong et al. 2004).

Indirectly, stronger positive attitudes could happen as a result of a reduction on perceived risk as found by Heidjen, Verhagen et al. (2001).

The effect on attitudes has great significance in terms of overall consumer behaviour. Ultimately, it is expected that consumers shopping for products in environments with multimedia product experience and comparison tools will consider online shopping more often.

9.9 Perceived quality of decisions

Around the inception of Internet shopping, some researchers predicted that because of extensive product information, consumers would feel better and more confident about their choices (Alba, Lynch et al. 1997). Both CT and IMPE did increase the overall quality of participants' purchases. However, did they perceive that their choices were better?

According to the present study, only CT had this effect. Being able to compare products by either their search or experience attributes seem to affect positively the way participants feel about the quality of their decisions. This benefit matches predictions of consumer behaviour studies: when it becomes easier to compare products, consumers become more confident about their choices. An expected consequence of that is that perceived risk is reduced.

Interestingly, there was no such effect for IMPE. It can be speculated that perhaps the feeling of not being efficient (in the IMPE condition) is related to this finding. Alternatively, in terms of perception, the static pictures together with text seem to be sufficient to create a feeling of reaching a good decision. So, participants could feel that static pictures and text are enough for the website to convey relevant product information that allows consumers understand and evaluate product quality and performance at a sufficient level. This is a very interesting finding as to show that perception does not necessarily match behaviour.

9.10 Perceived knowledge

In the consumer behaviour literature, usually consumers' product knowledge is analysed in terms of objective knowledge and perceived knowledge (Lee, Hong et al. 2004). Objective knowledge is the accurate information consumers have, while perceived knowledge refers to people's perceptions of what or how much they know about a product or product class (Park, Mothersbaugh et al. 1994). Differences in objective and perceived knowledge occur when people do not accurately perceive how much or how little they actually know (House, Lusk et al. 2004). A common find is that the less perceived knowledge a consumer has the more amount of information is acquired to make purchase decisions. This would impact consumer decisions, as those with higher perceived knowledge are less likely to search for information about a product before coming to a decision to purchase.

The results from this study show that IMPE affect learning (objective product knowledge), but does not affect self-assessed, perceived knowledge. This may show what Park, Mothersbaugh et al. (1994) found - that the amount of experience with the product mediates perceived knowledge, in the sense that an extended product experience (e.g., using the product for a period of time) can influence objective knowledge, but a limited experience may have little or no effect. Multimedia experience can influence decision quality, but it has no effect in producing change in both perceived product knowledge and perceived quality of the decisions, although their objective corresponding measures (learning and decision quality) showed improvements.

On the other hand CT has a marginally significant effect on perceived knowledge. This is in contrast with learning, as CT had no effect on learning. So the perceived knowledge consumers report does not correspond to an actual measurement in terms of learning, another case where perception of reality and reality itself do not seem to match entirely. We can speculate that CT could give the false sense of learning as it facilitates greatly the decision-making process. So consumers make better decisions in less time, and consequently believe they learn more. Again, it must be stressed this result shows only a tendency, being partially supported.

9.11 Interactive Multimedia Product Experience

Despite the fact that participants in the IMPE conditions took more time to complete the tasks than the ones in the SMPP conditions, they had more positive outcomes in other variables, something that can be considered as an unexpected result. Previous research in consumer behaviour and at least one study in e-shopping (Lee, Kim et al. 2000) found that transaction costs (in this case, time) do not affect consumer satisfaction for high involvement products - consumers will search more and spend more time, because they consider the product of greater relevance to them. However, since involvement was found not be correlated with any of the outcomes, there must be something else affecting these results. One possibility is that participants felt engaged with the way multimedia experience allowed them to inspect the product.

Visual and behavioural inspection, and the information they yield can be simulated vividly in an interactive multimedia environment where consumers can not only examine the product visually but also functionally. As a result, multimedia experience enhances a consumer's ability to acquire knowledge, form attitudes, and influence behaviour in comparison to non-interactive static media product description.

Contrasting the effects of IMPE v. SMPP, a possible explanation is that the former is more conducive to elaborative processing than the latter. Because text is present in both situations, they are both processed through verbal and pictorial channels following Paivio's (1991) dual-coding theory. By having the interactive, exploratory feature, the animations encourage elaborative encoding which can enrich the stimulus, therefore making it easier to learn the information (Nisbett and Ross 1980).

It is interesting to see that participants in the multimedia condition did not perceive their decisions to be of better quality, though, objectively, their decisions were clearly superior. The same happened with knowledge: they learned more, but there is no effect on their perception.

It is important to make a clear distinction between animations and interactive animations. Sometimes, researchers reach the conclusion that there is no measured difference between animations and still images. Morrison, Betrancourt et al. (2000), for example, analysed several studies on animations and concluded that there is no advantage of using animations over static graphics even for dynamic information. The same authors (Morrison and Tversky 2001; Tversky, Morrison et al. 2002) presented a set of experiments where they showed that animations are not superior to static graphics. The problem with their analyses and experiments is that they explicitly did not consider interactive animations, only passive animations. It can be argued that, had they considered interaction, and their results would have been different. Their explanation for the failure of animations is based on the fact that animations are difficult to comprehend because they are transitory; they disappear and consequently are difficult to be reinspected. The criticism that has to be made about this explanation is that this is not an inherent characteristic of the medium – it is a design feature. Designed appropriately, chunks of information can be reinspected for comprehension. Animations that are designed for the appropriate types of information, user, and task can be superior to static graphics, as the present study has shown. The advantages of having a high level of interactivity are related to the provision of autonomy to users in determining the materials they want to examine and the pace at which they feel more comfortable according to the task, interests and profile (Teo, Lih-Bin et al. 2003; Jiang and Benbasat 2007). Autonomy and flexibility can give the users a sense of control which reinforces positive user attitudes toward a system.

Najjar (1996a) described a meta-analysis of studies done in the educational field and concluded that the ones that did not support positive effects of multimedia on learning were due to design: they did not encourage elaborative encoding. In another meta-analysis study, Heder (2002) reached the same conclusion: that the (lack of) design of elaborative encoding may be a reasonable explanation for the inconsistent effects of multimedia on learning. In particular, multimedia that encourages the learner to elaboratively process the information (for example, by using both verbal and pictorial codes, relevant motion, or by requiring the learner to use more effort) may improve learning more than multimedia that does not encourage elaboration. The results from the current thesis confirm these findings – it is not the mere use of multimedia technology but how it is designed and used that improves learning.

Dual-coding theory (Paivio 1991) which is commonly employed to inform and understand media combination (Mayer and Moreno 2003) does not seem to include the concept of exploration. The empirical work in the present thesis for example, contrasts passive images and text against interactive animations. According to Paivio's theory, these two should produce similar effects. This supports the idea that it is the elaborative processing, rather than the multiple media alone, that can make it easier to learn information that is presented via multimedia.

In terms of electronic shopping, IMPE did have an impact on learning about products. When used to show the functionality of products, one possible effect it has on consumers is that it stimulates their sensory experiences, evoking memories and previous sensations, which could explain the positive impact they have on learning and behaviour. Daugherty, Li et al. (2005) obtained similar results using 3D product visualisations and, although they went further stating that these experiences can be a substitute for consumption, we cannot make these claims in this thesis.

In relation to the problems consumers experience while shopping (survey in Chapter 5), a consequence of making it possible for buyers to interact with representations of products is the reduction in uncertainty about the product quality, which, by extension, reduces the perceived risk connected with the product. It confirms some hypotheses raised in the literature (Kempf and Smith 1998; Jiang and Benbasat 2004; Pavlou, Liang et al. 2007) and shows that interactive multimedia is a viable way to reduce perceived risk for experience products.

Taylor and Thompson (1982) reached a conclusion that the vividness effect is surprisingly weak. They presented evidence (more than 40 studies) indicating that the impact of vivid descriptions was not consistently greater than nonvivid ones. The problem is that they measured the effects only on persuasion, whereas in this thesis vividness (i.e., naturalness) is used to overcome uncertainty. In addition to that, they did not consider design issues. In the present study, more naturalness that supported tasks prompted users to a more elaborate encoding process – a finding that is in line with the results obtained by Jiang and Benbasat (2007).

Not much can be concluded in terms of quality of information representation, as it was not manipulated in the study. All pictures and animations had a high level of representational quality not only of product demonstrations but also of what can be achieved with the products (in this case, quality of pictures taken with the cameras being described).

In terms of exploration, the IMPE allow consumers to actively acquire information at their own pace and style which is linked to a facilitation on learning processes (Jiang, Wang et al. 2005; Jiang and Benbasat 2007). They can select the contents they want to learn about, according to their particular needs. When consumers interact with online products, they are paying attention on how the products react to certain actions, and by doing so, they develop their understanding about products' features, while at the same time they learn about them. The reason for that could be that, because of the exploration feature, they develop a clearer, vivid mental image of the product which could facilitate learning (Schlosser 2003; Jiang and Benbasat 2007).

9.12 Comparison tools

The use of CT provides better accuracy with less effort, which sometimes can surprise researchers (Haubl and Trifts 2000). One of the novelties in the present work is the use of comparisons to support shopping tasks that are not covered by other studies. For example, none of the previous empirical studies cited in this chapter allowed consumers to compare products on their experiential attributes, which is a typical activity consumers engage when making complex decisions involving experience goods. Even the use of 3D models, as in the study by Haubl and Figueroa (2002), does not provide the level of interaction required to support activities like checking the usability of a given product.

Comparison tools that allow consumers to select and compare products side-by-side have a substantial impact on the way choices are made. These tools help consumers make not only more informed purchase decisions, but also better ones in less time, as the cognitive decision effort is reduced.

Without comparison tools users must get information about a product, learn the most important details, and either remember them or print them out; find another item, and do the same again. It is easy to see that not all main features of a product will be remembered, as cognitive load is substantially increased. One solution that advanced web users employ is to open several browser windows or tabs. They arrange them in order to see details of different products, moving from one window/tab to another. This is not a satisfactory solution, not only for novices that may not be aware of it, but also for experienced users who may need to open several pages, and can easily lose their way in the forest of windows.

9.13 Open-ended questions: what did they reveal?

The open-ended questionnaire participants answered after using the website revealed that:

- Comparison tools do support decision-making – the lack of their presence will frustrate consumers;
- Interactive multimedia product experience is not expected to be available, but when they are, consumers will benefit from their presence.

It is important to mention that participants did not know there were more versions of the website; they thought that what they used was “the website” being evaluated. Thus, they were not aware of what was being compared.

Participants who did not have comparison tools, faced difficulties while performing attribute based comparisons. Using a compensatory strategy to make the final selection was also affected. Therefore, the fact that they expressed the need for CT was expected.

Interestingly, participants in the passive static media condition did not state any need for multimedia product experience. This is a typical case where users become used to what is available and believe this is somehow good enough. On the other hand, for participants in the IMPE condition, this was the very aspect they liked most.

9.14 Limitations of the study

This work represents a substantial attempt to conceptualise and investigate an important area of HCI and electronic shopping. However, the results of the present research need to be viewed in light of potential limitations, which are inherent within any study.

9.14.1 Participants

Although there was enough care related to randomisation, the use of a student sample restricts the external validity and should be kept in mind when interpreting the results. On the other hand, the use of students as a population for our experiment increases the internal validity of the results as their homogeneity do not add extraneous variance to the behaviour in question (Greenberg 1987) .

Another point related to external validity is that real consumer behaviour in online shopping can be different in several ways from the one in a laboratory. For instance, although there was no correlation associated with involvement with the products tested, in real situations it can be an issue. Knowing that lab-based studies can potentially reduce ecological validity, care was taken to design a professional-looking website with real products. Even so, participants were not making real purchase decisions risking their own money.

The study was careful to check for correlation in terms of expertise and experience with e-shopping of the participants. However these variables can possibly be further explored to see to what extent they impact on behaviour. For example, Haubl and Figueroa (2002) found a positive correlation between prior shopping experience and the preference for 3D presentations of the products. This could be explained by the greater need for certainty the experienced shoppers have compared to shoppers with no previous online experience. This correlation was not found in the present study; a possible explanation is that in their work, participants were presented with two products side-by-side: one described with a static picture and the other with a 3D model. In the present study, the availability of the interactive product demo was manipulated between subjects.

An additional factor is individual differences in terms of processing style. In the experiment conducted by Lightner and Eastman (2002), information processing style was proposed as an individual characteristic that defines the propensity and preference to utilise either a verbal or visual modality processing information contained in one's environment. Lightner and Eastman tested the impact of the processing style on satisfaction for 3 types of product descriptions: diagrammatic-only (visual design elements), sentential-only (text), and a combination of diagrammatic and sentential. What they found was that the preferred processing style had no impact in satisfaction with a website. So, they do not see customisation of a website based on preferred processing style as necessary, since it does not produce a noticeable satisfaction enhancement. Another finding of this study was that 51% of the participants in the text-only condition requested pictures that showed the product. They claim that, while text is best to describe search attributes, pictures can help consumers form an idea of experience attributes, which is expected.

Another threat to the external validity in the present study is that participants are all residents from one country (i.e., UK). It would be helpful, thus, to replicate these results in different countries. Nevertheless, at least one study (Jarvenpaa and Tractinsky 1999) found similar patterns of online shopping behaviour among consumers from three different countries.

9.14.2 Choice of product

While strong consideration and planning took part in the selection of an appropriate product category, a limitation is the exclusion of numerous types of other products. As a result, these findings may not be generalisable to all products and situations.

This study, and consequently the implications derived from it, is based on a product – digital camera – that has the following important characteristics:

- a product associated with high perceived performance/functional risk,
- a product with an approximately equal balance of important search and experience attributes.

In this respect, the results of the study are more relevant to similar categories of products (e.g., electronic devices such as sports watches, satnavs, media players, etc). This limitation is intrinsic with the research in consumer behaviour, where there is no such thing as a typical or general product class (Smith and Swinyard 1983; Jiang and Benbasat 2004). An approach to increase external validity and the generalisability of the results is to run the study using different types of products and to measure the effects of multimedia and comparison tools relative to search and experience attributes separately.

Another design choice that can be seen as a potential limitation is the use of only one brand for all products. This is a simplification of the general case in which the consumer can select products from different brands. As already mentioned, this was introduced in the study to avoid any bias towards brands. Nevertheless, the design features proposed are extensible across brands.

9.14.3 Type of decision-making

Findings from this work are applicable to limited or extensive problem solving according to Solomon’s typology (Solomon 2011). Habitual decision-making was not addressed by this research. In addition to that, only goal-directed behaviour was considered, whereas in a number of occasions people engage in the so called experiential behaviour (Hoffman & Novak 96).

9.14.4 Novelty effect

As the animations used in the experiment were not familiar to participants, it could be the case that the novelty effect would explain the results. Newer media often have a slight advantage over conventional media, but this effect wears off after prolonged exposure to the novel medium (Buisine and Martin 2003). However, several new technologies, despite being new, are rejected by users. Consequently, this fact alone does not invalidate the findings from the study related to the usefulness of such technology. Furthermore, on trying to show that novelty can explain consumers' behaviour on 3D presentations, Edwards and Gangadharbatla (2001) devised an experiment where novelty was examined. Contrary to their hypotheses, they failed to attribute participants' behaviour and choice to novelty - 3D presentations had the same positive effects being it a novelty or not.

9.14.5 No prescription on how to implement the features

Another factor to consider is that the design ideas generated by the multimedia features proposed in Chapter 4 can be implemented in several ways. No prescription is given on the implementation side. So, the e-commerce prototype website built for this thesis is an exemplar of such an implementation, and not a perfect model in terms of form and behaviour to be followed. The ideas and concepts, on the other hand, are the true value of this endeavour. For example, new technologies that are available for designers such as mobile devices were not considered for this work. However, because the design features are generic, high-level and technology-neutral, all the features could be applied for such devices.

9.15 Implications

This research has implications for a number of settings within the realm of HCI, multimedia and consumer behaviour in an e-shopping environment. Understanding the effects multimedia and comparison tools have on decisions made by users will enable designers to build e-shops that improve the consumer experience. Moreover, HCI researchers will be able to investigate issues with a better understanding of a particular type of user - the consumer - and the phenomena that surround them.

The implications are discussed in terms of design and research.

9.15.1 Implications for system design

Effective design of user experience is a challenge. Specifically, the design of e-shopping environments with a view to optimising the value for consumers who are making their purchase decisions via the Internet is a critical issue. For this reason, it is important to understand the cognitive and perceptual phenomena that surround the interaction consumers have with e-shops in their search for goods. Findings from this thesis can enhance our understanding on how multimedia contributes to support tasks that are central to consumer behaviour in electronic commerce. By identifying product performance risk as one of the key factors contributing to problems encountered by consumers, and by investigating the use of multimedia with comparison tools, some implications for system design can be inferred.

From consumer behaviour research, it is known that consumers search for information as long as the benefits from search exceed its costs (Spiekermann 2001; Mowen and Minor 2002). From this viewpoint, consumers will continue searching only as long as the incremental gains that result from search are greater than the costs incurred to make the additional search. One of the reasons this is done is to reduce perceived risk. Interactive multimedia product experience is one way to reduce perceived risk for the category of products where functional inspection is important. Comparison tools are used both to reduce search costs, and to reduce perceived risk when comparing products' experiences.

Comparison tools seems to support elimination by aspects, where the consumer keeps track of exactly which options are still being considered, i.e., eliminating the ones that do not meet certain criteria. In certain situations consumers need to sort products using different criteria (e.g., price and resolution) in ascending and descending orders. This facility simplifies the weighted adding strategy, which is something that is usually considered difficult (Pereira 2001).

Designers should take particular care with the way information is presented, as it has a major impact on choices. For instance, consumers will acquire information in a manner consistent with the form that the list of alternatives is organised: by attribute or by alternative.

9.15.2 Implications for research

The current research provides implications for the HCI of e-shopping both in terms of research methods and increased understanding.

9.15.2.1 Research methods

One of the problems identified with research in e-shopping is that it is primarily done by the marketing community. HCI researchers have a lot to offer by placing the consumer at the centre of the design. In this thesis, this is exemplified by the use of a choice model, instead of a preference one, more favoured by marketing researchers. From a HCI view point, the study of consumer behaviour can be used primarily in generating hypotheses about consumer tasks and needs.

Based on the measurements of quality of decision-making contrasted to perceived quality of decisions, and of learning contrasted to perceived learning, i.e., observed data compared to perceived experiences, it is clear that both measurements are necessary for a more complete picture of users' behaviour and opinions. It supports the idea that collecting users' opinions does not give a complete idea of the whole experience; it is necessary also to observe what they do. The reverse is also true.

Methodologically, this research generated methods, analyses, and insights into HCI research in e-commerce. Future research can employ or build upon these ideas, saving time and effort.

9.15.2.2 Increased Understanding

Knowing the needs of consumers and the process they go through when making a purchase decision reveals that there has been very little attention given to a fundamental part of online shopping: the description of the product itself. By categorising products in terms of search and experience attributes, it is possible to identify the ones that would benefit most from specific support, including multimedia experience. Different types of attributes require different design strategies. This understanding would avoid the "one-size-fits-all" approach that prevails in many web stores, and would form the basis for decisions concerning the information provision that is customised according to product attributes and features. The way in which indirect and direct experience information is conveyed requires careful consideration to ensure that assessments are both easy to process and well justified.

Another important factor that needs to be taken into account is the level of uncertainty and type of risk associated with a product, as it does affect the purchase process. Again, the understanding of search and experience attributes can be used to model and reduce risk.

Because this thesis has raised issues for further inquiry, sharing this knowledge and methodology will potentially stimulate additional research in this domain, which is becoming increasingly important.

Buyer's uncertainty about the quality of the product provided by sellers has a central role in consumer decision making. Ultimately, the challenge for research in this area is to make accurate generalisations about the effects of electronic environments on decision quality so that designers can build websites that provide a well-grounded experience for a given task environment (Pereira 2000).

The results also support the idea that future research should measure different aspects of user experience. All are affected by the independent variables, and it is not enough to assume that efficiency and satisfaction are always correlated. Besides usability measures, the study showed that other consumer behaviour measurements are necessary to understand all the effects.

9.16 Summary

This chapter discussed the main results of the empirical work of the thesis. The findings support the notion that consumer experience is strongly contingent upon CT and IMPE. CT reflect the basic task of evaluating alternatives; if not supported, this task will be considerably less effective and efficient. IMPE allows consumers to inspect the product in its functional aspects. The combination of CT and IMPE supports additional shopping tasks: comparison of functionality (how it works) and comparison of performance (quality of pictures). Combined, they increase confidence in the decision, lowering the perception of risk.

We are confident that the variables measured affected the outcome measures. Due to external validity issues, care should be taken for the generalisation of the findings. In terms of theoretical developments, the findings have implications for the advancement of research and design, and for the understanding of current consumer behaviour on the Internet.

The next chapter presents the conclusions drawn from the research presented in this thesis and avenues for future work.

Chapter 10 Conclusions and Future Work

"I think and think for months and years. Ninety-nine times, the conclusion is false. The hundredth time I am right." Albert Einstein

This thesis has presented a theoretical, empirical and design research based investigation of interactive multimedia and electronic shopping aimed at informing the design of multimedia systems in general and of choice-based decision making in electronic shopping in particular.

This last chapter summarises the conclusions, reflects on its contributions, and suggests possible avenues for future work.

10.1 Conclusions

The thesis has addressed the problem with multimedia systems design and the use of interactive multimedia technology in electronic shopping decision making. The focal point was to try to answer these questions:

- What are the main characteristics of interactive multimedia systems that enable users to gain an appreciation of the things they represent?
- What design features are required to guide multimedia design?
- How can multimedia design features be applied to e-shopping?
- Does it generate a user-experience improvement?

In order to answer these questions we applied different research methods to the goals of the thesis:

Goal	Method
1. to identify design features of multimedia systems	theoretical and analytical investigation of multimedia systems
2. to understand the criteria designers use when making design decisions related to multimedia	interviews with designers and subsequent thematic analysis
3. to identify the main problems consumers face when shopping electronically	survey and investigation based on consumer behaviour theories and models
4. to understand consumer behaviour models and their relationship to e-shopping	analysis of findings from the consumer behaviour literature, and its application to e-shopping
5. to identify gaps in the research that has been done to benefit consumers	analysis of current studies in the area
6. to design and develop a realistic electronic store prototype using multimedia technology to make product inspections, applying the multimedia design features	reuse of existing realistic material that satisfies the criteria of product inspections
7. to assess the use of multimedia technology as a way to solve the main problem consumers have with e-shopping	design and execution of a controlled experiment with a prototype online store
8. to recommend to designers when to use multimedia technology for e-shopping	derivation of implications for design from the analysis of the literature, from the design of a prototype e-shopping website, and from the results of the empirical work

9. to advise HCI researchers on how to improve research in e-shopping	derivation of implications for research from the results of the experiment contrasted with findings published in the literature.

The main characteristics of interactive multimedia systems from a user-centred perspective have been raised in Chapter 2. Chapter 3 identifies the criteria professional interactive designers consider when they make decisions about multimedia; crucially for this thesis, it shows that considerations of users appear to be rare. Chapter 4 identified a set of multimedia design features. Chapter 5 introduced consumer behaviour and electronic shopping, the domain chosen to apply design features and to test hypotheses. Chapter 6 presented hypotheses for the use of interactive multimedia product experience and comparison tools, identified as key tools to support purchase decision-making. Chapter 7 described a prototypical e-shopping environment selling digital cameras designed with the application of multimedia features. Chapter 8 presented a controlled experiment using the prototype built. Chapter 9 discussed the results showing the effects found for multimedia and comparison tools. It was found that multimedia and comparison tools, as discussed in Chapter 9, have an impact on the way consumers make purchase decisions. The same chapter included implications for designers and researchers.

Answering the research questions above, it is the conclusion of this thesis that there are problems that are specific with the design of multimedia systems. The design features try to address some of these problems. By applying the features to a design of an electronic shop, multimedia improves the user-experience.

Specifically about e-shopping, the problem is that the products are not physically present. This constitutes a fundamental gap that users experience when shopping online for certain products, as it is difficult to judge their quality. The thesis showed that it is possible to improve the quality of interaction by providing product information through the use of multimedia.

The thesis analysed and organised issues on multimedia design and electronic shopping. Apart from critical analysis of current literature, other methods were used to understand the problem, derive design features, apply them in a particular domain area, and choose and evaluate hypotheses in order to provide new insights. Motivated by multimedia design problems, a new way of organizing the problem through six design features was proposed. The thesis also uncovered the criteria designers employ when making design decisions that involve multimedia. A domain area was chosen for its momentous relevance: electronic shopping. A major problem with e-shopping was then identified and a solution proposed. By applying the design features to interactive multimedia product experiences, a prototype system was developed to test hypotheses.

10.2 Summary of Contributions

The main value of the work reported in the thesis is to draw out the nature of multimedia systems for the benefit of people who interact with them. The thesis contributes to the field of multimedia design research within the HCI area through the provision of a set of design features that are candidates for the development of design principles. By understanding the needs of designers, these features have the potential to support designers in making better informed decisions about various media.

The thesis also focuses on issues in online shopping that belong to the intersection of HCI and consumer behaviour research. Bringing together knowledge, models, methods, tools and findings from these two disciplines, it aims to support consumers in their purchase decisions, specifically through the provision of better product information using multimedia technology. By improving our understanding of the use of multimedia in electronic shopping and of its effects in online consumer behaviour, the thesis contributes with insights to designers of online retail environments.

Contributions to design:

- Multimedia
    - Identification of problems with multimedia systems
    - Better understanding of multimedia design decision-making
    - Multimedia Design Features
        - Naturalness/Realness
        - Media Allocation and Combination
        - Redundancy
        - Significant Contribution of the Media
        - Exploration
        - Quality of Information Representation
    - Application of features to design
- Electronic Shopping
    - Assessment of Interactive Multimedia Product Experience

Contributions to research:

- Multimedia
    - Better understanding of problems with multimedia systems
    - Avenues for the development of principles based on design features
    - Insights into multimedia design decision-making
- Electronic Shopping
    - Better understanding of consumer-computer interaction
    - Use of choice model instead of preference model

For designers of interactive systems, multimedia features can potentially offer more design options that match information type, user type, task, and media. In the case of e-commerce, the thesis suggests the use of interactive multimedia product experience as a mechanism for consumer learning about certain types of products. It provides useful insights into what types of products are more suitable for using multimedia experience (i.e., experience products that carry performance risk with higher levels of uncertainty that can be reduced with functional inspection); and what to expect in terms of user experience with the product decision-making process. Comparison tools are useful and preferable in order to compare products in terms of experience attributes as well as search attributes.

For researchers, the present work contributes with a better understanding of multimedia design and multimedia design decision-making. It is also a unique work using a choice model to study decision making for experience products. Furthermore, it provides insights into the area consumer behaviour that does not have much attention from the HCI research community.

10.3 Future Research

"Prediction is very difficult, especially about the future."

Niels Bohr

Multimedia design is a complex activity; it is not possible to try and solve all problems at once. In 2007, Sutcliffe stated that "multimedia still poses many issues for further research … considerable research is still necessary before we fully understand the psychology of multimedia interaction" (2007, p. 410). This researcher believes these statements are still valid today.

Electronic shopping, considered "one of the most influential economic forms in our age" (Tian and Stewart 2008, p. 6), has been, with a few exceptions, neglected by the HCI research community. Grudin made an attempt to explain that:

> *"Marketing - a discipline that engineers trust even less than Design! But branding and other forms of marketing are integral to human-computer interaction. HCI will reluctantly focus on the often startling issues raised by marketing. For example, a Web-page visitor wishes to find and handle information quickly, but commercial sites benefit by trapping eyeballs. The principles are known—supermarkets place commonly purchased items far apart, department-store escalators force you to walk briefly on each floor—but they introduce methodological issues and value conflicts for HCI professionals who see themselves as user advocates." (Grudin 2007, p. 49).*

This dilemma could explain the lack of research interest, but at the same time, leaves almost all research in the hands of the marketing and advertising community (Mittal 2005). This researcher believes there are several opportunities for HCI research in this area.

Many avenues have emerged from the work described in this thesis to be taken further, to fill the gaps in our understanding. This section describes some of the main opportunities and challenges that this work provides. By the nature of the empirical work performed, most opportunities identified are related to electronic shopping.

The multimedia features presented in this thesis need to be assessed and refined in different circumstances, different classes of systems and domains, and by other designers. Its utility and usability will come with its generalizability. It is hoped that future dissemination of this work to designers and researchers will lead to its use in real world design settings. It is also hoped that the features can generate principles that guide designers making more informed media choices. In terms of potential applications that go beyond electronic shopping, interactive multimedia can be applied to different domains such as physics simulations for science education (e.g., interacting with objects in the Moon to understand the concept of gravity) and fault diagnosis (e. g, remote fault diagnosis systems of aircraft during flight).

By definition, non-interactive media cannot be used to create IMPE. However, an interesting study would be to compare IMPE with video. Given the current state of technology, producing a video involves less resources and effort than producing an interactive animation; while there are many tools for the design of animations and videos, adding interactivity to provide exploration for each product is not well supported (Jiang and Benbasat 2007). Research that aims to investigate theories and processes that can guide the design of IMPE and identify requirements for the development of these tools is therefore welcome. The challenge is to design the support for exploration with meaningful activities that follow specific goals with clearly defined steps to achieve them (Meij and Carroll 1998).

Some authors claim that objects that can be manipulated virtually (in the same fashion as in an IMPE) create "the same effects and the same feel as manipulating the thing being represented" (Hutchins 1986, p. 99). Schlosser (2003) has suggested that consumers' direct interactions with virtual products result in feelings that the interaction events are occurring in a physical world. It was not the purpose of this thesis to test such hypotheses - further work needs to be done involving real and virtual products. Going beyond functional inspection of products, one can think of haptic or tactile inspection (e.g., for clothes). It would be interesting to see how the technology evolves, and study its effects on e-shopping.

It is still to be seen if IMPE will ease consumers' uncertainty when shopping for products that carry higher levels of performance and financial risks (e.g., an expensive telescope). Lee and Lee (2011) hypothesise that IMPE will only be effective up to a point: if uncertainty is too high, consumers will not rely solely on information gathered from the internet as it would be not enough to compensate for consumers' uncertainty.

This thesis has not examined the role of product reviews from other consumers. Reviews have been shown to enhance trust in the merchant; consumers use online reviews to infer product quality and reduce uncertainty (Hu, Pavlou et al. 2006; Xu and Kim 2008). However, most of the research done has concentrated on the impact of reviews on product sales (Hu, Liu et al. 2008). From a HCI perspective it would be interesting to see how it helps or hinders consumers (e.g. cognitive effort to balance positive and negative opinions) and how it affects decision-making (e.g. are all reviews given the same weight?).

The approach of this thesis is mainly of a rational human behaviour; nevertheless, decision making is influenced by many other factors, some of them not entirely rational. Although very interesting as a research avenue, behavioural economics is a complex subject that is beyond the scope of this thesis. Taking into consideration that there are several different aspects related to the shopping activity, the main approach of this thesis, while considering the purchase decision-making process, is a cognitive one. However, several studies in product choice (Jarvenpaa and Todd 1996; Jiang and Benbasat 2004) link the cognitive side of it to its affective side, establishing a high correlation between consumer satisfaction with product diagnosticity and consumer satisfaction with the affective aspects of shopping. This suggests that a cognitive-only view may not be that restricted, and warrants an investigation if this also happens for online environments.

One factor that has not been studied in depth is the user profile. As reported in Chapter 4, several user characteristics can affect the experience in general. More specifically in e-shopping, the classification of consumers might have an effect on the need for product inspection. For example, in dealing with risk reduction strategies, we have to take into consideration that what one consumer considers important for risk reduction may be irrelevant to another (e.g., risk-takers v. risk-avoiders) (Spiekermann and Parachiv 2002). Either perceived risk or acceptable levels of risk could be different, requiring different strategies of product learning. Some consumers want to inspect the product in details, while others only require a high level idea of the product. These differences could range from product class expertise to risk. Design has to consider these differences, being flexible in its depth of details.

The time and costs associated to experience the multimedia representation of each product limits the number which can be feasibly evaluated. That is, the sum of all costs (including the opportunity cost of time spent searching) could become disproportionate to the utility of the good. This requires more research to determine the cost and benefit trade-offs.

The thesis focused on the decision-making process of a purchase decision when a set of alternatives are selected. Research in this area should also investigate phase I of evaluation of alternatives, where screening a great number of alternatives and forming a consideration set is the main goal. The way to support consideration set formation seems to be a good candidate for future research considering that choice-overload seems to be a very controversial topic (Scheibehenne, Greifeneder et al. 2010).

Although trust was not directly addressed by this thesis, it should be noted that perception of site quality is now considered to be the primary influence on trust (McKnight, Choudhury et al. 2004). This suggests that supporting consumer decision-making in an adequate way will also potentially produce a positive effect on trust (Egger 1998; Fogg and Tseng 1999; Hoffman, Novak et al. 1999; Jarvenpaa, Tractinsky et al. 2000; Riegelsberger and Sasse 2002; Steinbrück, Schaumburg et al. 2002; Strinbruck, Schaumburg et al. 2002; Riegelsberger, Sasse et al. 2003a; Riegelsberger, Sasse et al. 2003b), and consequently on perceived risk (Jarvenpaa, Tractinsky et al. 2000). Gefen, Rao et al. (2003) go further arguing that in the context of low risk items, it is trust and not perceived risk that determines purchase intentions. They state that for higher risk items, risk perception becomes more important. Increasing trust is therefore a contributing factor to reduce risk perception, but not the Holy Grail that will eliminate risk for all products. It seems that IMPE can contribute to both risk and trust perception in different ways – it is hoped that future research can investigate this issue.

Contrasted with a hedonic use of an e-shopping website, this thesis focused on its utilitarian use. One could argue that users visit websites not only for utility, but also for entertainment (Huang 2003). The hedonic aspect relates to the users experience in terms such as fun, playfulness and pleasure. Promising work-in-progress has been reported on the effect of aesthetics on consumer behaviour (Cai, Xu et al. 2008) – the authors hypothesise that expressive, more creative aesthetics will have stronger effects for hedonic shopping tasks, while classical aesthetics will have stronger effects for utilitarian tasks. Results are still to be reported.

Culture is another factor that can influence the usefulness of IMPE. In a recent study comparing attitudes consumers from China and Singapore have towards e-shopping (Sangwan, Siguaw et al. 2009) found that their motives to shop online is significantly different: Singapore buyers are more positively inclined toward online shopping. This shows fascinating insights into cultural differences that could have more consequences for the design of e-shopping experiences, including IMPE.

Recently the popularity of mobile devices (e.g., smartphones) made M-commerce or mobile commerce area very prominent (Tian and Stewart 2008). While the multimedia features are technology-independent, it is important to understand how consumers use these devices to shop. The fact that consumers could be shopping in real stores at the same time as they get information about products on mobile devices is a recent phenomenon that requires more investigation.

Consumption decisions are generally not made out of a social context; many social factors can influence decision making. Research on the role of social networks in consumer behaviour is on-going (Guo, Wang et al. 2011) – in this case another type of risk - social risk - a product carries should be examined.

Technological advances of multimedia are not giving signs of slowing down; research needs to keep pace with it. It is a good sign that in the most recent ACM International Conference on Multimedia held in 2011, a panel discussed how to increase the quality of multimedia user-experience (El-Maleh, Wang et al. 2011). Initiatives such as Universal Multimedia Experience (Waltl, Timmerer et al. 2010) emphasize that multimedia should adapt to the user needs and not the other way around – an initiative to be supported.

In 1967, Newell, Perlis and Simon stated that “computer science is the study of computers. The phenomena surrounding computers are varied, complex, rich” (Newell, Perlis et al. 1967, p. 1373). More than four decades later, computers are part of nearly every part of modern society and the phenomena surrounding computers now include the activities of users. In recent years HCI have been following this expansion, incorporating new phenomena created by new technology. Landauer pointed out that “problems raised by technology raise curiosity that drives scientific research” (1995, p. 297). Ultimately, human beings strive to improve the way they live. As observed by Olson & Olson (2003, 511) "the field of HCI is at the center of the evolution of effective tools to improve the quality of our lives". This thesis, hopefully, has offered a contribution towards this goal.

Appendix PP

Pre-questionnaire

The purpose of this questionnaire is to categorise all the participants in this experiment. There are no right or wrong answers, but please be sincere. We respect your privacy and all individual data will be kept confidential.

1. Age: _______

2. Gender: ☐ M ☐ F

3. How long have you been using a **computer**:
   a) ___ weeks
   b) ___ months
   c) ___ years

4. How long have you been accessing the **web**:
   a) ___ weeks
   b) ___ months
   c) ___ years

5. How many <u>hours</u> a week do you use a computer?
   ☐ Up to 1 hour
   ☐ 2-5 hours
   ☐ 5-10 hours
   ☐ 10-30 hours
   ☐ Over 30 hours

6. How often do you access websites?
   ☐ Several times a day
   ☐ Once a day
   ☐ Several times a week
   ☐ Once a week
   ☐ Several times a month
   ☐ Once a month
   ☐ Less than once a month

7. How long do you typically spend on the internet each time you use it?
   - ☐ Up to 2 minutes
   - ☐ 2-5 minutes
   - ☐ 5-10 minutes
   - ☐ 10-30 minutes
   - ☐ 30 minutes – 2 hours
   - ☐ Over 2 hours

8. Have you ever bought anything on the web? ☐ Yes ☐ No

9. How often do you **make a decision** to purchase (or not to purchase) a product/service based primarily on information that you have gathered on the web *whether or not you use the web to make the purchase*?
   - ☐ Never
   - ☐ Less than once per month
   - ☐ 1-2 times/month
   - ☐ 3-5 times/month
   - ☐ 6-9 times/month
   - ☐ 10 or more times/month

10. Why don't you purchase (more) products on the web? (please, check all that apply)
    - ☐ Never tried it
    - ☐ Too complicated to place order
    - ☐ Difficult to judge the quality of a product/service
    - ☐ Faster/easier to purchase locally
    - ☐ Not familiar with vendor
    - ☐ Don't trust that my credit card number will be secure
    - ☐ No receipt/documentation
    - ☐ Not enough information to make a decision
    - ☐ Generally uncomfortable with the idea
    - ☐ Heard it’s not a reliable/secure/trustworthy way to make purchases
    - ☐ Had a bad experience in the past
    - ☐ Don't trust that my personal information will be kept private
    - ☐ Don't have a credit card
    - ☐ Prefer to deal with people
    - ☐ Difficult to find appropriate web sites
    - ☐ Site doesn't offer the option to purchase
    - ☐ No one home to receive the delivery
    - ☐ Other reasons

10. Do you own a photograph camera? ☐ Yes ☐ No (**go to question 12**)

11. What kind of camera? (check all that apply)
    - ☐ Basic point-and-shoot
    - ☐ Compact camera with zoom and/or some control
    - ☐ APS
    - ☐ Underwater
    - ☐ SLR (single-lens reflex) with full control
    - ☐ Digital
    - ☐ Other

12. How many pictures have you ever taken with a ***digital*** camera?
    - ☐ None
    - ☐ 1-10
    - ☐ 11-50
    - ☐ More than 50

For questions 14 to 16, circle the appropriate number. If you are undecided or can't make up your mind (and only in these situations), then circle the middle number.

Rate your attitude towards digital cameras.

Strongly unfavourable Strongly favourable

1…………..2…………..3…………..4…………..5…………..6…………..7

13. Rate your attitude towards shopping on the internet.

Strongly unfavourable Strongly favourable

1…………..2…………..3…………..4…………..5…………..6…………..7

14. I feel very knowledgeable about digital cameras.

Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

Instructions for the next two items:

To measure your involvement or interest in some items, we need to judge them against a series of descriptive scales according to how **you** perceive the item. To use the scales;

If you feel that it is *very closely related* to one end of the scale, you should check a box as follows:

important ☒....☐....☐.....☐.....☐....☐....☐ unimportant

or

important ☐....☐....☐.....☐.....☐....☐....☒ unimportant

If you feel that it is *quite closely related* to one end of the scale (but not extremely), you should check a box as follows:

appealing ☐....☒....☐.....☐.....☐....☐....☐ unappealing

or

appealing ☐....☐....☐.....☐.....☐....☒....☐ unappealing

If you feel that it seems *only slightly related* (but not really neutral) to one end of the scale, you should do as follows:

uninterested ☐....☐....☒.....☐.....☐....☐....☐ interested

or

uninterested ☐....☐....☐.....☐.....☒....☐....☐ interested

Important:

Be sure that you <u>mark every item</u>. Please do not omit any.

Never put more than <u>one mark on a single item</u>.

Make <u>each item a separate and independent judgement</u>. Work at a fairly high speed. Don't worry or puzzle over individual items. It's <u>your first impressions</u> and immediate feelings about the items that we want. On the other hand, please do not be careless, because we want <u>your true impressions</u>

Shopping on the web

important	☐....☐....☐.....☐.....☐....☐....☐	unimportant
irrelevant	☐....☐....☐.....☐.....☐....☐....☐	relevant
means a lot to me	☐....☐....☐.....☐.....☐....☐....☐	means nothing to me
valuable	☐....☐....☐.....☐.....☐....☐....☐	worthless
uninterested	☐....☐....☐.....☐.....☐....☐....☐	interested
unexciting	☐....☐....☐.....☐.....☐....☐....☐	exciting
appealing	☐....☐....☐.....☐.....☐....☐....☐	unappealing
fascinating	☐....☐....☐.....☐.....☐....☐....☐	not fascinating
not needed	☐....☐....☐.....☐.....☐....☐....☐	needed
involving	☐....☐....☐.....☐.....☐....☐....☐	uninvolving

Digital Camera

important	☐....☐....☐.....☐.....☐....☐....☐	unimportant
irrelevant	☐....☐....☐.....☐.....☐....☐....☐	relevant
means a lot to me	☐....☐....☐.....☐.....☐....☐....☐	means nothing to me
valuable	☐....☐....☐.....☐.....☐....☐....☐	worthless
uninterested	☐....☐....☐.....☐.....☐....☐....☐	interested
unexciting	☐....☐....☐.....☐.....☐....☐....☐	exciting
appealing	☐....☐....☐.....☐.....☐....☐....☐	unappealing
fascinating	☐....☐....☐.....☐.....☐....☐....☐	not fascinating
not needed	☐....☐....☐.....☐.....☐....☐....☐	needed
involving	☐....☐....☐.....☐.....☐....☐....☐	uninvolving

Please, be sure you answered all questions!!

If you have any questions related to one or more items, please ask now.

If you are finished, please tell the administrator of this questionnaire.

Appendix QQ

Tasks

1) Your friend, John, has a Kodak camera and you know he's happy with the brand (he says he likes the quality of the cameras and the results he obtains with them). The last time you met him, he mentioned being interested in buying his first digital camera and asked for your advice. His budget is £200 and he also asked you to be sure it was an easy to use, simple camera that produces good quality pictures.

a) Which camera would you recommend to John?

b) Can you offer him a second choice?

2) The insurance company Delta has several Kodak DC280 digital cameras that are used by claims inspectors. They are in need to buy a new lot of cameras; the technical adviser recommended the cheaper DC3400, instead of the DC280. When consulted, the inspectors disapproved the decision, because they're happy with the quality of DC280 and don't want to spend too much time learning how to use another camera, even if it's cheaper. Check how the 280 and the 3400 work.

a) Which one is harder to setup? 280, 3400, no difference, don't know

b) Which one is more difficult to take pictures with? 280, 3400, no difference, don't know

3) You need to recommend a pocket-size camera to a friend. Based on specification and quality of the pictures produced, which cameras would you select, in order of preference?

a) Select a camera

b) Select a camera

4) The department of archaeology needs a digital camera for their field expeditions. Can you recommend them a camera, considering that they want to produce high quality pictures, but also that their expeditions can be in dirty and wet places and in extreme weather conditions?

a) select a camera

5) Check how to take a picture with the DC3800.

a) In the setup mode, there are several options in the menu. What is the purpose of the FORMAT option?:

1. Changes the format of the picture
2. Chooses between landscape and portrait
3. Reformats picture cards
4. Selects the menu format
5. Don't know

b) What should you do to have a preview before taking the picture?:

1. It's not possible to preview the picture
2. Press OK button
3. Press shutter button half-way
4. Turn the mode dial to capture
5. Press down the menu button
6. Don't know.

Appendix RR

Post-questionnaire

Questionnaire

Instructions:

After using the website, please fill in this questionnaire. It consists of 39 items. Consider them carefully and answer each one using the provided options. There are no right or wrong answers, but please be sincere. The information you provide is kept completely confidential.

Please indicate your agreement or disagreement with the statements by **circling the appropriate number**. If you are undecided (and only if you are undecided), then circle the middle number.

---

1. I will return to this site, if I need a digital camera of this brand.
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

2. If a friend needs to search for a digital camera of this brand, I will recommend this website.
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

3. Using this website is frustrating.
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

4. Tasks can be performed in a straightforward manner using this website.
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

5. I would like to see other websites similar to this one for other products.
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

6. In case I need a digital camera from this brand, I would purchase from a website like this.
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

---

7. It was very easy to perform the tasks (e.g. select a camera, …).
Strongly disagree Strongly agree
1…………..2…………..3…………..4…………..5…………..6…………..7

8. It was very easy to find specific information.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

9. It was very difficult to navigate the site.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

10. Using this website, it is very easy to assess the ease of use of a particular camera.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

11. It is very easy to compare the ease of use of these cameras.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

12. It is very difficult to compare the specifications of the cameras.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

13. It is very easy to assess the picture quality taken with a single camera.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

14. It is very easy to compare the quality of the pictures taken with these cameras.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

---

15. My ability to find information out about the cameras was better to what it would be like visiting the shop myself.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

16. I was able to appreciate what it would be like to use one of the cameras.
Strongly disagree Strongly agree

1………….2………….3………….4………….5………….6………….7

17. My experience of using any of the cameras was very bad.
Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

18. It felt as if I tried the cameras.
Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

---

19. How do you rate this web site?
Bad Excellent

1…………..2…………..3…………..4…………..5…………..6…………..7

20. Rate your attitude towards digital cameras after using the website.
Unfavourable Favourable

1…………..2…………..3…………..4…………..5…………..6…………..7

21. Describe your overall impression of these cameras.
Unimpressive Impressive

1…………..2…………..3…………..4…………..5…………..6…………..7

22. Describe your overall impression of the picture quality produced by the cameras.
Unimpressive Impressive

1…………..2…………..3…………..4…………..5…………..6…………..7

23. I trust the information presented in this website.
Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

24. Rate your attitude towards shopping on the internet
Unfavourable Favourable

1…………..2…………..3…………..4…………..5…………..6…………..7

For questions 25 to 30, use the figure below.

				
DC3800	EZ200	DC280	DC5000	DC4800

				
DC3400	DC215 - Silver	DC215- Gold Millenium	DC290	DC240


DC3200

25. How strongly do you believe that the DC4800 produces the best pictures among this group of cameras?

Don't believe   Very strongly

1…………..2…………..3…………..4…………..5…………..6…………..7

26. How strongly do you believe that the DC280 is the cheapest camera?

Don't believe   Very strongly

1…………..2…………..3…………..4…………..5…………..6…………..7

27. How strongly do you believe that the DC5000 is the sturdiest camera?

Don't believe   Very strongly

1…………..2…………..3…………..4…………..5…………..6…………..7

28. How strongly do you believe that the DC3400 has more resolution than the EZ200?

Don't believe   Very strongly

1…………..2…………..3…………..4…………..5…………..6…………..7

29. How strongly do you believe that it's easy to take pictures with the DC3400?

Don't believe   Very strongly

1…………..2…………..3…………..4…………..5…………..6…………..7

30. Based on the pictures taken with the EZ200, how strongly do you believe they are of excellent quality?
Don't believe Very strongly

1…………..2…………..3…………..4…………..5…………..6…………..7

---

31. How confident are you about the recommendation you made for the insurance company Delta (DC280 x DC3400)?
Not very confident Very confident

1…………..2…………..3…………..4…………..5…………..6…………..7

32. How difficult was it to identify which product best met the needs?
Very difficult Very easy

1…………..2…………..3…………..4…………..5…………..6…………..7

33. How adequate was the quality of information about the cameras for your decisions?
Not adequate Very adequate

1…………..2…………..3…………..4…………..5…………..6…………..7

34. How adequate was the quantity of information about the cameras for your decisions?
Not adequate Very adequate

1…………..2…………..3…………..4…………..5…………..6…………..7

35. How confident are you about the recommendations you made?
Not very confident Very confident

1…………..2…………..3…………..4…………..5…………..6…………..7

---

36. I feel very knowledgeable about digital cameras
Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

37. If a friend asked me about these cameras, I wouldn't be able to give him/her advice about them.
Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

38. If I had to purchase a (Kodak) camera today, I would need to gather very little extra information in order to make a wise decision.
Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

39. I feel very confident about my ability to tell the difference in quality among the different cameras.

Strongly disagree Strongly agree

1…………..2…………..3…………..4…………..5…………..6…………..7

Please, be sure you checked all the scales!!

If you are finished, please tell the administrator of this questionnaire.

Thank you very much for your time and effort.

Appendix SS

Learning Test

The purpose of this questionnaire is to measure what you can remember from using the website. Please select the letter which represents the best answer for each of the following questions. Try to give your best answer, without using the website.
We respect your privacy and all individual data will be kept confidential.

1. The main feature(s) of the DC5000 (see picture) is/are (multiple choices):

A) pocket-size
B) zoom of 6x,
C) robust, sturdy body
D) works as a web camera as well
E) highest resolution among the cameras
F) weather proof
G) don't know

2. Put these cameras in ascending order of price:

<table>
<tr><td>a) 
DC3800</td><td rowspan="7">1. (   )
2. (   )
3. (   )
4. (   )
5. (   )
6. (   )
7. (   )</td></tr>
<tr><td>b) 
EZ200</td></tr>
<tr><td>c) 
DC280</td></tr>
<tr><td>d) 
DC5000</td></tr>
<tr><td>e) 
DC4800</td></tr>
<tr><td>f) 
DC3400</td></tr>
<tr><td>g) 
DC215 - Silver</td></tr>
</table>

3. What is the resolution, in megapixels, of the DC4800:

A) 3.1
B) 2.0
C) 4.5
D) 1.0
E) 2.5
F) don't know

4. Irrespective of price, which camera would you choose for you?

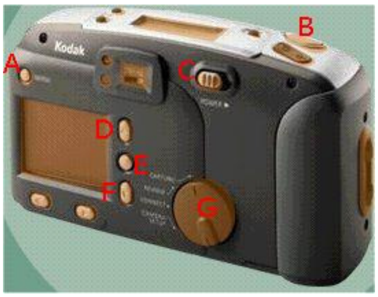
a) DC215-Gold
b) DC290
c) DC3800
d) EZ200
e) DC240
f) DC3200
g) DC280
h) DC5000
i) DC4800
j) DC3400
k) DC215-Silver
l) I would need to have another look at the website

Why? (select one or more reasons)

a) Best picture quality
b) Easiest to use
c) Pocket size
d) Easiest to transfer pictures to a computer
e) Best lens
f) Most expensive
g) Its name suggests that it is the best camera
h) Other: ____

____

6. The picture below is from the DC3400. Which button would you press to have an instant preview of the picture on the LCD display?



A)__ B)__ C)__ D)__ E)__ F)__ G)__ H) don't know

Appendix TT

Open-ended questions:

1. What information would you like to see on this site that doesn't already exist?

2. What information/tool was most helpful? What part of this website do you find most interesting/useful?

3. What tasks would you like to be able to perform with this site that you are currently unable to perform?

4. What did you like most?

5. What you didn't like? Any suggestions for improvement?

6. What are the advantages of shopping online?

7. What are the disadvantages of shopping online?

8. Which products would be best suited for this kind of website?

Appendix UU

Experiment of E-Shopping Website

Researcher responsible: Mr Fabio Nemetz (PhD Student)

Email: F.Nemetz@bath.ac.uk

Purpose of the study: this study investigates the way in which people use a specific website. At the end of the study, you will be able to ask questions.

Please read these statements:

- you may withdraw from the study without penalty at any time by advising the researchers of this decision
- personal data provided will be confidential, and no personal identification will be stored;

I agree to participate in this study.

Name: ____________________________________

Signature: ___________________________________

Date: _____/______/__________

Researcher: Fabio Nemetz

Signature: ___________________

Date: _____/______/__________

Appendix VV

UNIVERSITY OF BATH

Consent Form for Interview Study

INFORMED CONSENT TO PARTICIPATE IN INTERVIEW WITH INTERACTION DESIGNERS

About this interview

This interview is being conducted by Fabio Nemetz (F.Nemetz@bath.ac.uk) for the Department of Computer Science at the University of Bath. Potential benefits associated with the study include a greater understanding of designer's decision making process related to the use of different media. If you decide to participate, you can withdraw from the test at any time without any penalty.

Confidentiality

The interview will be recorded in audio for analysis purposes only. Your data will be stored anonymously to protect your privacy.

Participation agreement

If you agree to participate in this interview as described, and for any relevant responses to be used in publications anonymously, please indicate your agreement by writing your name, e-mail address, then sign and date below. Thank you for your participation in this research.

Name: ______________________________________

E-Mail: ______________________________________

Signed: ______________________________

Date: ____________________

Appendix WW

Interviewee Profile

Participant number: ________ Date: ______________ Time: ____________

Place: ____________________ Age: _______ Gender: M ☐ F ☐

Company/freelancer/consultant:
____

Current position/occupation:
____

Company age: _____ Size of company (approx. number of employees): ____________

Daily tasks/responsibility:

Experience with interaction design (years and activities):

Education:

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